INTRODUCTION

Since the first snowmobiles entered Yellowstone National Park in 1963, the number and types of winter recreationists have steadily increased. While media attention has focused on Yellowstone National Park, winter recreation on public lands throughout the Greater Yellowstone Area (GYA) has increased as well, for example snowmobilers in the Lionshead/Two-Top, Island Park, and Cooke City areas; skiers around Cooke City and Teton Pass; and snowshoers, dog sledders, and resort skiers throughout the ecosystem. Many of these activities have experienced explosive growth in the last decade.

In 1990, Yellowstone and Grand Teton national parks issued the *Winter Use Plan* for the two parks following public involvement and an environmental assessment. At the time, winter visitation in the parks was about 123,000 visitors. The plan forecast that winter use of the parks would not increase quickly and would not reach 140,000 (the high projection) for 10 years. However, that use level was reached by the 1992–93 winter, and, as directed by the plan, the parks began to address use levels by developing a process to assess visitor use.

Because winter use of the parks is only a portion of the winter use that occurs in the GYA, the other members of the Greater Yellowstone Coordinating Committee (GYCC) shared many of the same concerns of park managers. In April 1994, the GYCC chartered a team made up of staff from Yellowstone and Grand Teton national parks and Gallatin, Targhee, Shoshone, Bridger–Teton, Custer, and Beaverhead–Deerlodge national forests to study winter visitor use issues and to develop an assessment of use. This assessment, titled *Winter Visitor Use: A Multi-Agency Assessment*, showed that human use is not only increasing, but it is also expanding into areas that received little or no use in the past. Groomed snowmobile trails as well as some cross-country ski trails, particularly on national forest lands, are being expanded to accommodate this increase.

In 1995 the national parks conducted a scientifically based survey of its visitors. While many activities were listed as important, 93 percent of visitors to Yellowstone and 89 percent of visitors to Grand Teton rated wildlife as “very important” or “extremely important.”

Land managers, area residents, and the visiting public are concerned about the effect that the current levels of winter recreation may be having on the natural environment and wildlife. Human activities continue to expand into wildlife habitats. To minimize the impacts of these activities, wildlife managers need to be aware of the effects of these activities and to understand how to mitigate for them.

While much of the information in this document will be useful in areas beyond the GYA, the document does focus on many issues specific to this area. For example, one task accomplished through the visitor use management process was to describe the entire Greater Yellowstone Area in terms of Potential Opportunity Areas (POAs). Potential Opportunity Areas describe an area’s recreation potential, not necessarily its existing condition. The experiences range from those that are easily accessible and highly developed to those that are considered remote backcountry experiences. Complete descriptions of POAs can be found in Appendix II. How wildlife could be affected in various POAs is described in this review.

The purpose of this document is to provide guidelines for managing winter recreational use in the context of preserving wildlife populations. Several topics are discussed, including the current population status and trend of the individual species, relevant life history data, information on winter habitat use, summaries of studies on the influence of human activities on individual species in the winter, and the potential effects of specific winter recreational uses on those species. Papers that were peer-reviewed prior to the compilation of these papers are noted as such. All papers were subject to a joint review process by biologists and managers before being submitted to the final editing process.

MAMMALS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BIGHORN SHEEP

POPULATION STATUS AND TREND

Bighorn sheep (*Ovis canadensis*) were historically found throughout the mountains of western North America. Prior to the arrival of European man, their population is estimated to have been between 1.5 and 2 million. Bighorn sheep numbered fewer than 42,000 in 1974 (Wisthart 1978 in Reisenhoover et al. 1988). This decline was caused by competition with livestock, introduction of diseases, hunting, and loss of habitat during European settlement of the West (Buechner 1960, Keating 1982). With the establishment of management areas and hunting regulations, bighorn sheep have reoccupied some of their historic ranges, although populations have not reached pre-settlement sizes.

The creation of Yellowstone National Park in 1872 provided needed protection for the Rocky Mountain bighorn. In the early 1900s, fewer than 150 bighorn sheep were thought to exist in Yellowstone, and by 1912 managers estimated that 200 bighorns were in the park (Seton 1913, Mills 1937). Presently, bighorn sheep are found in limited areas of suitable habitat throughout the Greater Yellowstone Area (GYA); estimates of their numbers are included in Table 1. Larger populations are found along the eastern boundary of Yellowstone, with some populations having more than 1,000 animals.

Table 1. Estimated bighorn sheep population sizes in the Greater Yellowstone Area

Location	Estimated Number
Yellowstone National Park	240–325
Gallatin Mountains	50–65
Upper Yellowstone River, North of Yellowstone	60–75
Absaroka Mountains, Montana	130–175
Absaroka Mountains, Wyoming	4,190
Grand Teton Mountains	100–150
Madison Range	40–50
Gros Ventre Range	550
Wind River Mountains	900
Wyoming Range	75–100
Estimated Total	6,335–6,580

Today, bighorn populations continue to have some of the same problems that bighorns had when European settlers first arrived. In the winter of 1981–82, a chlamydia (a contagious infection of the eye) outbreak on the Mt. Everts winter range in Yellowstone reduced the bighorn population by more than 50 percent, from 487 to 159 (Meagher et al. 1992, Caslick 1993). Since that time the bighorn population has increased only slightly, and in 1996, 167 bighorns were observed on the same winter range surveyed before the outbreak (Lemke 1996).

Other populations in the GYA have declined as well (Jones 1994; Legg 1996; L. Irby, Montana State University, personal communication; S. Stewart, Montana Fish, Wildlife and Parks, personal communication; L. Roop, Wyoming Game and Fish Department, personal communication). The most recent decline was noted in the Madison Range population near Quake Lake, Montana, during the winter of 1996–97. It is believed that disease, predation, and human impacts such as illegal hunting, loss of habitat, and winter recreational use of winter ranges have contributed to these declines.

The loss of habitat and the fact that bighorns use traditional migration routes are the primary problems facing bighorn sheep today and are often mentioned as concerns for bighorn sheep management (Constan 1975; Horejsi 1976; Martin 1985; Reisenhoover et al. 1988; Environmental Protection, Fish and Wildlife Service 1993).

Life History

Adult ewes become mature at 2½ years. The breeding season occurs from November through late December, typically on winter range. Lambing occurs from mid-May through June, either near the winter range or during spring migration (May through July), and often along steep, precipitous cliffs. Fall migration is from October through December. The timing of both migrations depends upon weather and snow levels. Bighorn sheep typically remain in separate ewe/lamb and ram groups except during the rut. Males leave ewe/lamb groups between age 2–3.

Habitat

Bighorn sheep utilize different ranges in the winter and summer, and they have an established migration route between these areas. The knowledge of these traditional ranges and migration routes is passed down from one generation to the next. By a bighorn's fourth year, it has learned its band's traditional home ranges and migration patterns (Geist 1971, Reisenhoover et al. 1988) and will use them the rest of its life. Any alteration of these habitats or routes could be detrimental for a population of bighorn sheep.

The amount of available winter range for Rocky Mountain bighorn sheep is usually more limited than the amount of summer range because of snow depth and spatial distribution. Because of this, winter range can be the critical habitat factor in the survival of bighorn sheep. Bighorns typically use lower elevation ranges in the winter because of low snow coverage in these areas, although some winter at higher elevations on windswept south-southwest facing slopes, usually above the thermocline (Oldemeyer et al. 1971). These higher elevation winter ranges can be problematic because bighorns have limited access to forage. The greater snow depths surrounding the small, available areas of forage habitat make movement from patch to patch difficult.

Habitat features that are important for bighorn sheep survival include the distance to escape terrain, slope, salt availability, elevation, aspect, forest cover, shrub availability, biomass and nitrogen content of palatable grasses, and snow depth/snow pack.

Human Activities

Protecting critical winter range by limiting human impacts is important for maintaining bighorn sheep in the GYA. Winter recreational use near or on bighorn sheep winter ranges may affect bighorns during the rut, during winter on the winter ranges that have limited amounts of available habitat, or in the spring during the lambing season.

The following types of recreational use could potentially affect bighorn sheep: hikers, wildlife photographers/observers, ice climbers, hunters, snowshoers, skiers, snowmobilers, sled dogs, and dogs on or off leashes. On ranges where bighorns are hunted, they are more sensitive to the presence of humans (Horejsi 1976). Any human activity on bighorn sheep winter range, especially within 100 yards of escape terrain, could affect bighorn sheep survivability.

Recreational activities may cause stress in bighorn sheep leading to increased heart rate and energy expenditures (MacArthur et al. 1982) and/or cause displacement from preferred foraging areas to less optimal habitat (Horejsi 1976, Hicks and Elder 1979). Bighorns typically forage during the warmest part of the day to minimize energy loss. If bighorns alter their foraging activities either spatially or temporally, they increase their exposure to predators, decrease the quality and quantity of food available to them, and increase their energy loss. Any decrease in energy intake or increase in energy expenditure as a result of human recreational activity may lead to the death of an already winter-stressed animal either directly by starvation or indirectly by lowering resistance to diseases or predation. The effects of human recreation can be considered an additive factor in lowering survivability in bighorns (Horejsi 1976).

MacArthur et al. (1982) showed elevated heart rates and fleeing behavior in bighorn sheep when approached by humans. This behavior was very apparent when humans surprised the bighorns or at any time dogs were present. The heart rate of the bighorns did not decrease with successive approaches, although if a predictable human behavior occurred (*i.e.*, direction and timing of approach), the bighorns became habituated and little response would be noticed except when a dog was present. If bighorns had been harassed earlier by a predator or human then the current harassment caused a greater response than normal.

In Montana, snowmobiles may have contributed to a decline in a bighorn sheep population in the Rock Creek drainage. The stress from the snowmobilers added to the natural stresses incurred during the winter (Berwick 1968). Human disturbance was also found to be a limiting factor for a population of bighorns in the Sierra Nevada Range. Herd size, human distance to the bighorns, and the elevational relationship of humans to bighorns were important factors in determining the reaction of bighorn sheep when approached by humans (Hicks and Elder 1979).

Boyle and Samson (1985) noted that rock climbing on or near bighorn sheep escape terrain can affect bighorns. Horejsi (1976) believes that improved access and more leisure time has increased recreational activities (from snowmobiling to walking the dog), which has resulted in more harm to wild bighorns. Because humans behave differently than natural predators (they often persist in following the bighorns to their escape terrain), they can displace bighorns from traditional areas.

There is the possibility that bighorn sheep may sometimes congregate near humans as a protection from predators, although the harassment by humans has to be less than the chance of predation. Along the Gallatin Ridge trail, there are two bighorn sheep summer ranges in the Hyalite and Tom Miner basins. There are many areas of bighorn habitat along the 30-mile-long ridge, but bighorn sheep were observed at locations having high visitor use relative to the rest of the area (Legg 1996). In winter, bighorns may not use the human/predator relationship to select habitat, as winter habitats are already limited to a few select areas.

POTENTIAL EFFECTS

Recreationists may cause increased stress for bighorn sheep during critical winter months, which may influence their survivability. Human use on the winter range during the breeding season could interfere with breeding by adding more stress to the rams and ewes. This may decrease the overall productivity of the population and increase the probability of predation and death.

Bighorns may abandon high quality winter range that is used heavily by humans, or they may limit their use to a small area near escape terrain. These limitations will decrease the available habitat used by bighorns or push them into areas with a greater potential for predation. If bighorns are unable to forage during the day because of recreationists, they will use more energy to forage when it is colder. Development on winter ranges or along migration corridors will decrease the already limited habitat available for bighorns.

During the lambing season ewes could be pushed into less optimal habitat, exposing the lambs to predators and environments with harsher weather.

Bighorn sheep in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(2) Primary transportation routes
(3) Scenic driving routes
(6) Backcountry motorized areas
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

- Human approach to the critical areas of bighorn habitat should be limited. A buffer zone should be established around bighorn sheep escape terrain.
- Human activities should be limited to roads or trails to minimize disturbance to bighorn sheep (MacArthur et al. 1982).
- Dogs should be prohibited on any bighorn sheep winter range (MacArthur et al. 1982).
- The remaining bighorn sheep habitat should be protected to ensure that migration corridors will remain intact and that traditional ranges are maintained.
- Special protection measures should be enforced during brief critical periods such as breeding, lambing, and severe winter weather (Boyle and Samson 1985).
- Activities such as ice climbing, wildlife photography/observation, and hiking that occur on lower elevation winter ranges should be monitored very closely. If there is any indication that bighorn sheep are being displaced either spatially or temporally, the activities should be stopped or managed to protect the bighorns.
- Skiing, snowmobiling, mountaineering, and snowshoeing will most likely only affect bighorn sheep wintering at higher elevations. The encounters between these recreationists and the bighorns may be infrequent enough that there would be little or no impact to the animals. However, if use increases at these higher elevation winter ranges, managers need to monitor the situation in order to prevent the loss of bighorn sheep on isolated winter ranges.

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EFFECTS OF WINTER RECREATION ON BISON

POPULATION STATUS AND TREND

Bison (*Bison bison*) once roamed most of central North America and are native to the Greater Yellowstone Area (GYA). In the 1870s and 1880s, bison were nearly eliminated by market hunting; only a few small isolated populations remained. In Yellowstone National Park, poaching further reduced bison numbers, and, in 1902, 23 bison were counted in the Pelican Valley area of the park. To preserve the species, park managers imported 21 bison from captive herds in Montana and Texas and intensively managed the animals at the "Buffalo Ranch" in the Lamar Valley using livestock techniques. By the winter of 1926–27, the bison population had grown to more than 1,000 (Meagher 1973).

The ranching operation ended in the mid-1930s, when National Park Service (NPS) policy shifted from simple preservation to conservation of species in more natural conditions. The captive herd then intermingled with the remaining wild bison herd that survived in Pelican Valley. From the late 1930s through 1967, NPS managers utilized herd reductions to achieve range management goals. In 1967, when manipulative management of wildlife populations ceased, 397 bison were counted in the entire park. Bison numbers were then allowed to fluctuate in response to environmental factors. Since 1967, the bison population increased to a peak of 3,956 in the winter of 1994–95 and then declined to 3,398 in the winter of 1995–96.

In 1968, in response to livestock industry concerns about the disease brucellosis, the NPS proposed a program to control bison at the boundary of the park. Hazing, herding, baiting, physical barriers, and scare devices were used to discourage bison from leaving the park, generally with little success (Meagher 1989). Shooting bison was used as a last resort. From 1968–84, only a small number of bull bison were removed as they attempted to move beyond the park boundary. Beginning in 1985, the state of Montana used hunting to control bison moving from the park into Montana. In the severe winter of 1988–89, following summer drought and area fires, hunters in the state of Montana shot 569 bison as they left the northern portion of the park. Bison continued to leave the park each winter in varying numbers, and, in the extremely severe winter of 1996–97, Montana state officials and park rangers shot or captured and sent to slaughter 1,084 bison. This, added to estimates of 300–400 dying from such natural causes as extreme weather, winter kill, and starvation, brought the total bison population in Yellowstone down to an estimated 2,000 animals in spring 1997 (NPS 1998). After reproduction, the early winter population count was 2,105 bison for the winter of 1997–98.

LIFE HISTORY

Bison are highly social animals. Females and subadults wander together in large herds with bulls, singly or in small bands, on the periphery of the group. The rut occurs in late summer (July and early August), and calves are born in April and May. At a few hours of age, a calf can keep up with its mother (Meagher 1973).

A large bison bull may stand six feet at the shoulder and weigh 2,000 pounds. Female bison are similar in appearance to males, although they are smaller and have more slender horns that point forward. Bison have a heavily muscled neck that supports a massive head, which is swung back and forth in winter to move snow from forage.

HABITAT

Bison are grazers and consume large amounts of sedges and grasses. Bison do use forested areas. In winter bison are typically found in open meadows and thermally influenced areas. Yellowstone's bison winter in three fairly distinct areas with some overlap of animals between the wintering areas at various times during the year. These wintering areas are called the Northern (Lamar Valley), the Mary Mountain (Hayden Valley–Firehole River), and the Pelican Valley.

HUMAN ACTIVITIES

Winter recreational use can have several impacts on wildlife. These include harvest of animals (via trapping, hunting, poaching), habitat modification, pollution, and disturbance. These impacts can have a number of effects on wildlife species, including behavioral change or death. Behavioral change may consist of altered behavior, altered vigor, or altered productivity. The abundance, distribution, and demographics of populations can be affected, and this can result in changes in species composition and interactions among species (Knight and Cole 1995). Alteration of wildlife movements or displacement from normal wintering areas can result in higher energetic costs for winter-stressed wildlife, potentially decreasing production of young. Occasionally, direct mortality may occur as in the case of snowmobile–wildlife collisions.

There have been various studies related to winter recreation and its impact on wildlife as evidenced by recent literature reviews by Caslick and Caslick (1997) and Bennett (1995). However, there are few completed studies that specifically focus on the effects of winter recreation on bison.

POTENTIAL EFFECTS

MOVEMENTS

Bison establish a network of trails and travel routes in the winter as the snow depth and crust become severe. Bison often use rivers, streams, and marshes for travel as well as packed and groomed snowmobile trails (Aune 1981, Bjornlie and Garrott 1998). Groomed trails may be used extensively by bison; snow-packed roads used for winter recreation in Yellowstone National Park may be a major factor relating to the expanded distribution of bison in the park (Meagher 1993). According to Aune (1981), bison utilized groomed snowmobile trails regularly to travel from place to place. Bison were not observed using ski trails. Bjornlie and Garrott (1998) and Kurz (1998) also found that bison use the groomed roads as part of their network of trails; however, the majority of bison movements took place off of established roads and trails.

DISPLACEMENT

The most dramatic physiological defense response is observed when wildlife are provoked by humans on foot (Gabrielsen and Smith 1995, Cassirer 1990). The magnitude of the response depends on the distance, the movement pattern of the person(s), and the animal's access to cover. Animals will respond in a passive or active manner, depending on species and the particular situation.

In their initial response to human disturbance, bison usually "freeze" body movements, and there may be increased interaction among the bison group (Aune 1981). However, bison will also flee in response to disturbance; they usually flee by galloping or trotting away from the source of the disturbance (Aune 1981). The visual stimulus of a snowmobile or skier seems to initiate the flight response. Except for coyotes, Aune (1981) and Cassirer (1990) found that all wildlife species observed (mostly big game) reacted more quickly to an approaching skier than to a snowmobile, and the flight distance was generally greater from skiers. Bison were found to respond dramatically to skiers who were off established trails. All wildlife species studied, including bison, were wary of people on foot.

Most snowmobile–wildlife encounters occurred either early in the day (between 8 and 10 a.m.) or late in the day (between 5 and 6 p.m.). Most snowmobile–bison interaction occurred because of the bison's presence on groomed trails, and the number of interactions increased with snow depth (Aune 1981). Many bison flee when they encounter snowmobiles because they are "herded" down the trail by snowmobilers. Heavy human activity may temporarily displace wildlife from areas within 63 yards of the trail (Aune 1981). Heavy human activity sometimes occurs in areas that are winter range for big game such as bison. Snowmobile use is often more predictable and localized than skier activity and may cause less displacement of animals. Varied topography and good cover may reduce the frequency and intensity of displacement. Even a natural barrier, such as a river, may result in higher tolerance of snowmobile activity.

ENERGY EXPENDITURE

Winter recreational activity may significantly increase wildlife's expenditure of fat reserves. At the time of Aune's (1981) study, wildlife species in this area were dramatically increasing in population size, so the impact of winter recreational activity was apparently not influencing reproductive success. In some situations, wildlife may become habituated to human disturbance and the physiological responses decrease (Gabrielsen and Smith 1995). Wildlife, including bison, that are habituated gradually during the first two weeks of human disturbance (Aune 1981) may expend less energy when disturbed after that time.

Bison may use groomed snowmobile trails, packed trails, and plowed roads for travel through areas where surrounding snow is deep. However, bison may not use these trails if the packed routes are not within foraging areas or do not lead to them (Bjornlie and Garrott 1998). These types of routes facilitate bison movement by making movement more energy efficient. Bison may no longer be "snowbound" in locations where they have had to spend the winter in the past. Increasing numbers of bison have adapted to snow-packed roads and are using them as a travel route to access forage sites (Meagher 1993). Despite the presence of snow-packed roads, bison continue to use natural corridors, such as riverbanks where snow depth is ameliorated (as along the Madison) or the riverbed itself, to reduce energy expenditures.

Bison in the GYA are particularly affected by human use of the following Potential Opportunity Areas (POA):

(4) Groomed motorized routes
(5) Motorized routes

Bison may also be an issue in POA (3) scenic driving routes. This depends on the effect that plowed roads have on bison movement, and how long this has been occurring. The road to Cooke City from Mammoth has been plowed since the 1940s. This road traverses the northern winter range. This area is considered big game winter range due to lesser snow depths in winter. Bison are known to travel on the plowed road, but it is unknown if the road facilitates travel to winter ranges that were not used by bison in the past or allows them to exit from areas where the snow becomes too deep.

There may be some concern in areas where cross-country skiing occurs, primarily POA (9) backcountry nonmotorized areas, because of the potential for stressing bison in the winter and causing energy loss.

CONTINUING RESEARCH

There are several bison research projects ongoing in the GYA, including:

1. Determining forage availability and habitat use patterns for bison in the Hayden Valley of Yellowstone National Park.
2. Seasonal movements and habitat selection by bison in Yellowstone National Park.
3. Development of aerial survey methodology for bison population estimation in Yellowstone National Park.
4. Spatial-dynamic modeling of bison carrying capacity in the greater Yellowstone Ecosystem—A synthesis of bison movements, populations dynamics, and interactions with vegetation.
5. Population characteristics of Yellowstone National Park bison.
6. Bison interactions with elk and predictive models of bison and elk carrying capacity, snow models, and population management scenarios in the Jackson Valley.
7. Bison use of groomed roads in the Hayden Valley and Gibbon Canyon to Golden Gate areas of Yellowstone National Park.
8. Statistical analysis and synthesis of 30 years of bison data.
9. The effects of groomed roads on the behavior and distribution of bison in Yellowstone National Park.
10. Assessing impacts of winter recreation on wildlife in Yellowstone National Park.

MANAGEMENT GUIDELINES

- Where possible, consider rerouting snowmobile trails so that they are located outside of critical bison winter ranges and bison concentration areas.
- Where major bison migration routes intersect groomed snowmobile trails or snowmobile-use routes, consider relocating snowmobile trails or user routes.
- If bison are traveling plowed highways that have berms, plow frequent “pull-outs” where bison can escape from vehicular traffic.
- Increase interpretive contacts with snowmobilers, skiers, and snowshoers to educate these winter recreational users about off-trail use and wildlife responses.
- Consider restricting human use in areas of critical wildlife winter range.
- Continue to study the influence of packed trails on bison movement and distribution. Determine if this influence is acceptable where it varies from historical versus critical winter use.

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EFFECTS OF WINTER RECREATION ON ELK

POPULATION STATUS AND TREND

By the early 1900s, elk (*Cervus elaphus*) populations throughout North America had been decimated by commercial exploitation, competition with domestic livestock, and habitat changes. Most of the estimated 50,000 remaining elk were concentrated in the Yellowstone National Park (YNP) and Jackson Hole areas (Seton 1927). Protection of wildlife in YNP through installation into Yellowstone of the U.S. Army in 1886 and passage of the Yellowstone Park Protection Act in 1894 helped to reduce illegal killing in the park, and by the early 1900s the park's elk population began to stabilize or increase in number (Houston 1982, Robbins et al. 1982). Conflicts with livestock operations, combined with a series of severe winters that resulted in heavy losses of elk, caused continued concern about the future of the elk population that wintered in the Jackson Hole area (Robbins et al. 1982). In response to these concerns, Congress in 1912 passed legislation authorizing creation of the National Elk Refuge (NER) in Jackson Hole. Since the early 1900s, when management efforts were directed primarily at preserving and enhancing elk populations in the Greater Yellowstone Area (GYA), the management of elk populations has undergone several phases. In YNP, predator control, winter feeding, and effective protection from poaching resulted in a stable or increasing elk population (Houston 1982), which, in turn, created concerns about habitat degradation. Beginning in the 1930s and continuing until 1969, an average of 327 elk per year were removed from the park (Houston 1982), mainly from the northern range, through trapping for translocation and shooting. In 1969, the park placed a moratorium on elk removals (Cole 1969). That period marked the beginning of a management philosophy that continues to the present, in which the park has attempted to allow natural processes, to the maximum extent possible, to regulate ungulate numbers within Yellowstone. After the NER was established in Jackson Hole, the elk population there began to stabilize, although the number of elk in the adjoining Grand Teton National Park (GTNP) continued to decline until mid-century (Smith and Robbins 1994). Managers have been concerned about the large numbers of elk wintering on a restricted area in the NER and the impacts that they may have on forage supply and habitat quality. Therefore, an elk hunt was established on the refuge and in a portion of the adjoining GTNP (Smith and Robbins 1994). The states of Montana, Idaho, and Wyoming manage elk herds in the GYA by monitoring herd numbers and often herd composition, setting population and habitat objectives, and conducting regulated hunts. All of the elk herds in the GYA are subject to hunting in at least a portion of their ranges. Some elk that summer in YNP, which is closed to hunting, may be hunted as they migrate south to winter range (Smith and Robbins 1994). Most of the elk herds in the GYA were either stable or increasing during the 1980s (USFWS 1994), although a few have experienced declines in recent years. Populations south of YNP have been at or above stated population objectives in recent years.

Currently, an estimated 50,000–60,000 elk inhabit the GYA, in 10–12 separate herds (USFWS 1994). The northern Yellowstone elk herd summers in the northern and eastern portions of YNP and surrounding mountains, and as far south as Yellowstone Lake (Houston 1982). This herd's winter range extends from the Lamar Valley in the northeastern corner of YNP, north and west to the Dome Mountain

Wildlife Management Area outside YNP (USFWS 1994). This herd numbered around 20,000 in the early 1990s (USFWS 1994), but counts in 1998 and 1999 indicate that the northern herd currently numbers around 12,000 animals (Montana Fish, Wildlife and Parks, unpublished data; National Park Service, unpublished data).

A migratory herd of approximately 3,000–4,000 elk summers in the northern mountains of YNP and moves into the southern portion of the Emigrant elk management unit north of YNP during winter (MFWP 1992). This herd, which has been increasing in recent years, joins a resident herd of approximately 800–1,000 elk that summers in the Absaroka Mountains north of Yellowstone and winters in the foothills east of the Yellowstone River, north of YNP (MFWP 1992).

Three herds inhabit the area to the west and northwest of YNP. The Madison–Firehole herd resides year-round in the Madison and Firehole river drainages within and adjacent to the western boundary of YNP. Numbering approximately 600–800 animals (USFWS 1994), this herd is generally non-migratory (Craighead et al. 1973). Geothermal sites and thermally influenced areas are critical to the overwinter survival of this herd, which winters in a harsh area where snow depths peak at 115–150 cm annually (Craighead et al. 1973, Pils 1998). The availability of thermally influenced areas with associated reduced snowdepths may provide an upper limit to the size of this herd (Craighead et al. 1973). Another population of elk summers in the Gallatin and Madison ranges within YNP and west of the YNP western boundary and winters east of the Madison River in the foothills of the Madison Range (USFWS 1994). This population is believed to be increasing and was estimated at nearly 7,000 in 1992 (MFWP 1992). The Gallatin herd summers primarily in the northwest corner of YNP and winters along the Gallatin River in the Gallatin Canyon area in Montana (USFWS 1994). This herd numbers approximately 1,200–1,400 animals (MFWP 1992). Wildlife managers are concerned about increasing development on this herd's winter range in addition to a lack of security cover (MFWP 1992). A sub-population of the Gallatin herd summers at high elevations along the Gallatin Mountain Range and in the northwest corner of YNP (USFWS 1994). This group winters in the mountainous areas west of the Yellowstone River and northwest of the YNP boundary. The total Gallatin area elk population was estimated at about 2,900 during the early 1980s (USFWS 1994), and had increased to approximately 3,600–3,800 by 1992 (MFWP 1992).

Three elk herds along the eastern boundary of YNP summer primarily in the park. The Clark's Fork herd winters along the Clark's Fork River northwest of Cody, Wyoming, and numbered approximately 3,600 animals in 1988 (USFWS 1994). The North Fork Shoshone herd winters along the North Fork Shoshone River drainage west of Cody, Wyoming. This herd was estimated at roughly 2,900 elk in the late 1980s (USFWS 1994). The Carter Mountain herd winters in the Carter Mountain area and along the South Fork Shoshone River southwest of Cody, Wyoming, and consists of approximately 3,100 elk (USFWS 1994).

To the south and southwest of YNP and GTNP are three elk herds that spend all or part of the year in the GYA. Elk from the Targhee herd south of YNP summer generally outside YNP and winter along the Idaho–Wyoming border south of YNP (Mack et al. 1990). Approximately 500 elk were counted in the Targhee herd in the late 1980s (USFWS 1994). The Jackson herd, which winters on the NER and in the Gros Ventre River Valley, summers in the mountains to the north and east, including areas in Yellowstone and Grand Teton national parks and portions of the Bridger–Teton National Forest (Mack et al. 1990, Smith and Robbins 1994). From 1978 to 1982, roughly 7,600 elk wintered on the NER annually (Smith and Robbins 1994). The entire Jackson elk herd was estimated at approximately 16,000 animals in 1988 (USFWS 1994). The Sand Creek elk herd in eastern Idaho, which numbered approximately 4,200–4,900 in the mid- to late 1980s, summers east of Highway 20 in or near YNP, and winters in the Sand Creek winter range southeast of Dubois, Idaho (Brown 1985).

LIFE HISTORY

Elk are gregarious animals, and for most of the year males and females remain grouped in separate herds. Females begin to restrict their range and gather in traditional rutting areas in August and September (Martinka 1969), where, by early October, they are joined by males (Nowak 1999). During October males compete for females and attempt to gain and hold a harem of females through displays involving high-pitched bugles, antler thrashing, urine spraying, and fighting (Murie 1951, Geist 1982, Nowak 1999). Males may incur serious injury during the rut, which is usually done by late October. Many elk populations in the western U.S. migrate to low elevation winter range (Nowak 1999), where they may aggregate in groups of up to several thousand animals (Boyd 1978). The gestation period is roughly 250–265 days (Clutton-Brock et al. 1982, Taber et al. 1982), after which usually a single calf is born, generally in late May or early June (Murie 1951, Peek 1982). Sex ratio at birth is usually 1:1 (Peek 1982). Females may separate themselves from the larger herd to give birth in isolated areas, where they remain with their calves for several weeks (Boyd 1978). Lactation may last 4–7 or more months (Nowak 1999). Females generally attain sexual maturity at about 2½ years of age, and then are capable of producing a calf annually (Nowak 1999). Males are capable of mating at the same age, but most do not successfully breed until much later because of competition from older bulls (Nowak 1999). In wild populations few elk live longer than 12–15 years, with males often living shorter lives than females because of injuries incurred during the rut and decreased ability to deal with poor forage condition during the winter when they are nutritionally stressed from the rut (Peek 1982, Nowak 1999). In heavily hunted populations, the ratio of adult bulls to adult cows may be quite low (Peek 1982). The major source of mortality in most elk populations, including those in the GYA, is hunter harvest and associated crippling loss and illegal kills (Peek 1982). Wolves, cougars, and occasionally coyotes and domestic dogs may prey on both adult and calf elk (Murie 1951, Hornocker 1970, Carbyn 1983, Murphy et al. 1992, Gese and Grothe 1995). Both black and grizzly bears may be an important predator on elk calves in some areas (Murie 1951, Singer et al. 1997). Other sources of mortality are drowning, miring in thermal mud, fighting during the rut, entanglement in fences, and starvation (winterkill) (Murie 1951). Vehicle collisions also contribute to elk mortality in most GYA herds.

HABITAT

Skovlin (1982) described the basic requirements of elk habitat. Habitat selection is determined by topography, weather, vegetational cover, and escape cover. Elevation is probably the most important topographic influence, determining seasonal availability of habitats. The most important influences of weather on elk habitat use are snow depth and condition, which limit elk movement and forage availability. Vegetative characteristics that are important determinants of elk habitat use include cover for both thermoregulation and hiding or escape, as well as forage availability. Elk are an ecotone species (Skovlin 1982). Studies have shown that although elk are primarily grazers, their use of an area was higher when shrubs were intermixed with forest stands or where forest stands contained more than one successional stage (Lonner 1976). Ecotones provide a greater variety of forage plants used by elk, and more plants occur at a variety of phenological stages because of differences in microclimates where habitat types are intermixed (Skovlin 1982).

With the exception of the population in the Madison River drainage in and adjacent to YNP (Craighead et al. 1973), elk in the GYA are migrators, tending to return to the same winter and summer ranges year after year (Peek 1982). Although they are not migratory, the Madison River elk do exhibit seasonal changes in habitat use (Craighead et al. 1973). Migrating elk often follow the same travel routes, which are determined by topographic features and natural travel lanes (Adams 1982). Although movement to winter range is dictated primarily by increasing snow depth and density at higher elevations (Adams 1982, Farnes et al. 1999), summer and winter ranges fulfill differing habitat needs for elk.

Summer Range

Because of their large body size, elk have a relatively slow fattening rate, so summer range and the pulse of vegetative productivity between spring and the rut in autumn is of great importance in their ability to build up reserves with which to survive the winter (Geist 1982). Adult female elk face serious energy demands during lactation (Nelson and Leege 1982), which occurs while they are on spring and summer range. Grass is the most important forage type for elk during the spring greenup months, usually making up more than 85 percent of their diet (Nelson and Leege 1982). Grasses, forbs, and browse are all used to varying degrees during the summer, depending on availability (Kowles 1975, Nelson and Leege 1982). Leaves of browse species may also be consumed (Peek 1982). In addition to providing high quality forage, spring and summer range must provide opportunities for escape from biting insects as well as shade for escape from heat stress. Interspersion of cover to open areas appears to be important in determining calving areas because of the need for hiding sites used by newborn calves (Peek 1982).

Winter Range

Snow depth and snow characteristics appear to be the driving factors in the timing and rate of elk migration to winter range (Lovaas 1970, Adams 1982). Characteristics important in elk use of winter range include areas of low snow cover to facilitate movement and access to forage, escape cover from predation, and security from harassment and associated energy expenditures. Areas used by elk in winter are often low elevation valleys where snow accumulations are low, but may also include windblown ridgetops and thermal areas and thermally influenced habitats where snow depths are generally low and some green vegetation may be found year-round (Craighead et al. 1973). Adult females, calves, and younger elk of both sexes generally winter in large groups in low elevation habitats (Adams 1982). Some females calve while on winter range, in which case hiding cover for calves is of critical importance as described above. Adult male elk generally seek widely dispersed small patches of habitat providing nutritious forage that will build up lost energy reserves and recover from injuries incurred during the rut (Geist 1982). Bulls are often found on the fringes of winter range occupied by cow/calf groups (Peek 1982) or at higher elevations and in areas of greater average snow depth. This separation of the sexes on the winter range may help to reduce competition for limited forage (Peek 1982). Elk diets on winter range are influenced strongly by forage availability, which is in turn affected by snow depth and density. In general, elk prefer to consume dried grasses during the winter, followed in preference by browse species and then conifers (Nelson and Leege 1982).

HUMAN ACTIVITIES

Elk face many obstacles in surviving the winter, some of which can be compounded by the impacts of human activities. Winter is an energetically difficult time, in which elk must carefully balance energy expenditures against energy intake in order to survive. Forage quality is lower in the winter than at any other time of year. In experimental feeding trials most elk lost weight on diets that mimicked winter diets (Nelson and Leege 1982). Winter habitat quality may play an important role in the reproductive success of females. The overwinter nutritional condition of elk has been correlated with reproductive success. Thorne et al. (1976) correlated high winter weight loss in pregnant females with prenatal calf loss, low calf birthweight, and low survival of newborns. Poor winter diet may also be associated with poor milk production (Taber et al. 1982). Adult males usually enter the winter in relatively poor condition and often injured as a result of rutting activity in the fall (Geist 1982). Quality of winter habitat alone may determine whether some males survive the winter, when forage quality is at its lowest and often is least accessible (Geist 1982). Up to approximately 87 percent of the daily forage consumed by an elk in winter is used for standard metabolic function, leaving less than 15 percent for growth, reproduction, temperature regulation, and activity (Nelson and Leege 1982). Because of the low quality of winter forage, elk often rely on reducing energy expenditures to increase their chances of surviving and successfully reproducing (Marchand 1996). Movement through snow is energetically costly for elk, becoming considerably more costly as snow depth exceeds knee height (Halfpenny and Ozanne 1989). Farnes et al. (1999) reported that when snow-water equivalent, a measure of snow density, reaches 6 inches, elk are generally unable to continue foraging in that area and must move to areas of lower snow depth or density. Elk are apparently unable to crater through snow deeper than approximately 40 cm in search of food, and at greater depths they may switch to foraging on browse (Marchand 1996), which is generally a poorer quality food than grasses. After elk have foraged in an area, the disturbed snow around craters often becomes very dense and precludes further foraging in that area, forcing elk to seek other areas or other sources of food (Farnes et al. 1999).

Elk rely on fairly restricted winter ranges in which food and cover may be limited or of marginal quality, and, consequently, any activity preventing them from using all or part of that range could have negative impacts on their ability to survive or to successfully reproduce. In many areas within the GYA historic winter range has been settled by humans and converted into developments or agricultural uses. Human settlement on historic winter range may decrease the quality or availability of winter range, through changes in habitat, increased harassment by humans, or competition with livestock (Skovlin 1982, Taber et al. 1982). The NER was created in response to the fact that much of the historic winter range in the Jackson Hole area had been converted to agricultural and other uses, depriving elk of critical habitat needed to survive the winter. Human settlement in the GYA may already have restricted some elk herds to smaller or less productive winter ranges, putting them at greater risk of negative impacts from other forms of disturbance or displacement. Cows with calves generally winter at lower elevations than do bulls (Adams 1982), but low elevation valleys and river corridors are also the areas most often used by humans for settlement, agriculture, and road-building (Glick et al. 1998). Elk in the Madison–Firehole elk herd are extremely restricted during the winter, surviving in small patches of thermally influenced habitat along the Madison and Firehole river corridors (Craighead et al. 1973, Aune 1981). The groomed road between West Yellowstone and Old Faithful, however, transects the core of this critical winter habitat (Aune 1981).

Some research has been conducted into the effects of disturbance on elk behavior and movements. Elk in some areas have apparently changed traditional travel routes in response to human settlement and to hunting pressure, particularly on winter range (Picton 1960, Kimball and Wolfe 1974, Smith and Robbins 1994). Logging activity in some areas has increased year-round access for recreationists into elk habitat, which in some areas has resulted in changes in elk distribution (Skovlin 1982). Declines in elk use of areas within 0.25–1.8 miles of roads have been reported, with distances varying according to the amount and kind of traffic, quality of the road, and density of cover adjacent to the road (Lyon and Ward 1982). Avoidance of roads results in habitat near roads becoming effectively unavailable to elk (Lyon 1983). Ward et al. (1976) and Hieb (1976) state that harassment can be of concern because elk will readily desert productive habitats when disturbance is excessive.

When elk groups crossing highways en route to winter range are interrupted by traffic, they have been observed spending a great deal of time searching for the rest of the group before continuing directional travel (Adams 1982). Logging roads with associated debris piled along the edges have proven to be barriers to elk movements in some areas (Lyon and Ward 1982). This is likely to also be true of snow berms piled along plowed roads during the winter. Elk flight distances in reaction to humans varies by season, habitat, conditioning, and type of human activity (Skovlin 1982). When elk are disturbed by hunters, they may travel long distances before stopping (Adams 1982), sometimes up to 8 miles before reaching security cover or protected areas (Altmann 1958). Solitary elk appear to have longer flight distances than do groups (Skovlin 1982). Elk experience an accelerated heart rate during the alert state immediately preceding flight caused by harassment, car horns, gunshots, and sonic booms (Ward and Cupal 1979), but elevated heart rate has rarely been linked to changes in reproduction or survival (Ferguson and Keith 1982). Repeated flight, however, particularly through deep snow, uses energy reserves that might otherwise be used to help elk survive the critical final weeks of winter (Skovlin 1982). Lyon and Ward (1982) reported that logging activity occurring on elk winter range results in less movement by elk than logging activity on summer range does, possibly due to the reduced vigor of elk during winter, the difficulty of movement in deep or crusted snow, and the lack of alternative areas to which to move. Aune (1981) also observed that in YNP, elk were less likely to flee from snowmobiles or skiers late in the winter than they were earlier in the season. He suggested that this was likely due in part to habituation by elk to snowmobile traffic, and in part to decreased vigor of elk later in the season combined with the increasing difficulty of flight through deep, crusted snow. Proximity of escape cover that breaks the line of sight between elk and the disturbance may reduce flight distances and consequently the amount of energy used in flight. Moving automobiles and trail bikes had little effect on elk resting in timber at distances of only 0.13 miles (Lyon and Ward 1982).

Findings from studies of elk behavior in response to specific human winter recreational activities are varied. Ferguson and Keith (1982) researched the influence of cross-country ski trail development and skiing on elk and moose distribution in Elk Island National Park in Alberta, Canada. They found no indication that overwinter distribution of elk was altered by cross-country skiing activity. However, it did appear that elk moved away from ski trails, particularly those that were heavily used, during the ski season. Anecdotal observations indicate that elk may be relatively sensitive to the sight and sound of snowmobiles, moving away when only a few machines are present (Bureau of Land Management, unpublished data in Bury 1978). Anderson and Scherzinger (1975) reported that when recreational snowmobile activity increased in the Bridge Creek Game Management Area in northeastern Oregon, winter elk counts decreased by 50 percent. After the area was closed to snowmobiling, the population returned to its previous numbers. Aune (1981) found that heavy snowmobile traffic in YNP occasionally inhibited free movement of wildlife, temporarily displacing them from certain areas. The most significant impact on wildlife distribution appeared to be within 60 m of groomed snowmobile trails. Aune (1981) also reported that snowmobile activity in YNP resulted in average elk flight distances of 33.8 m, compared to average flight distances of 53.5 m in response to skiers. In another study, elk began to move when skiers approached to within 15 m in an area heavily used by humans year-round, and within 400 m in an area where human activity is much lower (Cassirer et al. 1992). Elk in YNP fled more frequently and over greater distances from skiers off established trails than from skiers on established trails (Aune 1981). During winter in Rocky Mountain National Park, elk were relatively undisturbed by visitor activities occurring on roads, but they exhibited longer flight distances from an approaching person than from an approaching vehicle (Shultz and Bailey 1978). Ward (1973) reported that elk are easily conditioned to repeated patterns of human activity, but tend to be disturbed by deviations from normal patterns. In YNP, Aune (1981) found that wildlife species, including elk, were more likely to be displaced by or exhibit flight responses to snowmobile traffic during the preseason when traffic was limited to occasional administrative travel than they were to the heavier traffic occurring during the recreational season. This may have resulted from habituation by elk to the presence of snowmobile traffic and to establishment of a more constant traffic pattern during the recreational season. This change in response may also have resulted from decreasing physical condition of elk later in the winter, and increasing snow depth and crusting that inhibited flight. Elk also demonstrated a shift to a more crepuscular activity pattern when recreational snowmobile activity increased (Aune 1981).

It has been suggested that the presence of groomed ski and snowmobile trails may provide a means for energy efficient travel for elk and other wildlife during winter. Ferguson and Keith (1982) found no indication that elk used groomed ski trails as preferred travel routes in Elk Island National Park, Alberta. Elk in the Madison–Firehole and Gibbon River corridors of YNP used groomed snowmobile trails increasingly as snow became deeper and more crusted and as animal condition declined through the winter (Aune 1981). Trails created by only one or two passes of a snowmobile and ungroomed ski trails, however, were not compacted sufficiently to support the weight of an elk and consequently were not used. Elk suffer greater chances of mortality from vehicle collisions when using roads and trails, particularly if they become trapped by plowed snow berms or other obstacles along road and trailsides.

POTENTIAL EFFECTS

Winter recreational activity can result in a variety of impacts on elk, depending on the nature and duration of the activity and the condition of the affected animals. Elk may readily habituate to predictable activity, so that recreational activities taking place on well-established routes and over a predictable time interval may have little effect on them after they become accustomed to the activity. Elk may learn to avoid areas of continual noise or disturbance, however, effectively removing a portion of otherwise available habitat from their use. This avoidance can have negative impacts on elk by reducing the amount or type of forage available and thereby adding to nutritional stress. Human activity occurring in low-snow areas may impact elk primarily because those areas are likely to be favored by elk late in winter when they are in poor condition. Antler hunting, for example, is an extremely popular activity during the late winter in many portions of elk habitat in the GYA, particularly on the northern range. This activity places humans generally on foot or horseback in low-snow winter range areas where bulls may be concentrated late in winter. The generally unpredictable, off-trail nature of this activity has the potential to create significant disturbance and stress to bull elk at a time when their energy reserves are at their lowest.

Conversely, elk may learn to use groomed roads or trails, and plowed roads as energy-efficient travel routes during the winter. It is not known whether the energy savings of using plowed and groomed roads and trails is greater or less than the costs of disturbance encountered while using such travel routes. Plowed roads may represent barriers to movement by elk if there are high snow berms on either side of the road, and may contribute to vehicle-caused mortality of elk using roads or trails. Roads may also provide energy efficient means of travel for predators in winter, increasing their ability to access prey and thereby increasing vulnerability of prey species such as elk.

Activities occurring in unexpected places or at unexpected times, such as skiing on lightly used trails or off-trail skiing, off-trail snowmobile use, or opening of previously closed areas can cause elk to flee, thereby using valuable energy reserves. Flight may be particularly costly for elk if snow is deep or crusted, or if elk are already in nutritionally stressed condition. Activity that occurs repeatedly but unpredictably may result in cumulative energy use over the course of the winter that might compromise an elk's ability to survive or reproduce. Repeated disturbance that does not result in flight may create stress in the form of increased heart rate and hormonal and other physiological changes, but any effects that these changes may have on overall survival and reproduction have not been well researched. The effects of disturbance by humans may be lessened if adequate hiding cover is available nearby. Disturbances that occur late in winter, when elk are in their poorest physical condition and the forage supply may be depleted, are likely to have a more negative impact than those occurring earlier in winter. Inability of elk to move through late-winter deep and crusted snow may compound the stress associated with disturbance at that time.

Elk in the GYA are likely to be affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. If such areas are newly created within elk winter range, they have the potential to displace elk from needed habitat. Elk may become accustomed to activity at destination areas if that activity is predictable. Irregular human activity at such areas may prompt flight response by elk in the vicinity.

(2) Primary transportation routes and (3) scenic driving routes. Transportation routes are often located in low-elevation areas and along river corridors, areas also often used by elk for travel and winter range. Habitat may become unavailable to elk through construction of transportation routes and through avoidance by elk of transportation corridors, particularly those that are heavily used. Routes with heavy traffic use or physical barriers along roadsides may interfere with elk travel and migration patterns. Vehicle collisions may result in mortality of individual elk.

(4) Groomed motorized routes and (5) motorized routes. Groomed routes are likely to have impacts similar to those of primary transportation routes and scenic routes, depending on the level of human use. Groomed routes may provide an energy efficient travel route for elk, but may also do the same for predators of elk.

(6) Backcountry motorized areas. Human activity in backcountry areas is likely to be less predictable than in other motorized recreation areas and, therefore, has more potential to create flight response in individual elk or groups of elk. Motorized use of these areas is likely to occur over a less-confined area than transportation routes, potentially increasing the area of disturbance or displacement of elk. This type of recreation usually occurs in higher elevation, deep-snow areas and so may impact only scattered groups of adult males.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. If use of these areas is predictable and confined to a defined area, elk may become habituated to the human activity occurring there. Nevertheless, elk could be displaced from areas immediately adjacent to groomed routes, and individuals or groups of elk may be prompted to flee from humans using such routes. Elk are more likely to flee from activity occurring on ungroomed routes because of the unpredictable nature of that use. Use of nonmotorized routes is, however, likely to be less frequent than that of groomed routes.

(9) Backcountry nonmotorized areas. Although use of these areas is unpredictable and, therefore, likely to produce flight response in elk, this type of use is likely to be infrequent enough to prevent recurrent stress of elk wintering in these areas. Backcountry skiing areas are also likely to be in higher elevation, deep-snow areas where fewer elk groups winter.

(10) Downhill sliding (nonmotorized). These areas are likely to be limited in number and size and are likely to be located adjacent to roads or groomed motorized trails. Disturbance associated with these areas is likely to be only slightly increased over disturbance from the transportation route used to access them.

(12) Low-snow recreation areas. One of the primary characteristics in elk choice of wintering areas is low snow depth. Therefore, human activities in these areas have potential to displace elk from important winter range. Elk may completely avoid such areas if human use is heavy or unpredictable, thus depriving them of access to forage and easy travel routes. Although habituation is possible to activities occurring in a predictable fashion, disturbance by humans can cause repeated flight response, causing stress and energy consumption by elk. Cows and calves generally winter in low-snow areas, and those affected by continued disturbance or displacement may suffer decreased reproductive success or ability to survive harsh winters.

Management Guidelines

- Avoid construction of new facilities in elk winter range and place any necessary construction in or adjacent to already disturbed areas. Elk winter range in many parts of the GYA is being converted to developments and other uses, so additional removal of winter habitat should be avoided.
- Regulate human activities so that they occur in defined areas in as predictable a fashion as possible. Elk may become habituated to regular human activity, decreasing flight response and consequent energy expenditure. Generally, moving traffic creates less disturbance than destination points or areas where humans are out of vehicles.
- Structure areas of human use and development so that there are buffer zones between humans and elk-use areas. Create or maintain sight barriers (brushy or forested areas) adjacent to human-use areas, thereby reducing the distance elk must flee to find hiding cover.
- Avoid placing transportation and motorized routes in low-elevation, low-snow, riparian, and open habitats favored by elk. Where this is necessary, attempt to occasionally move the route away from those areas and through denser timber or areas with adequate hiding cover. Avoid creating roadside barriers that may prevent elk from crossing roads or trails or that may trap animals along the route.
- Limit human activity in low-snow winter range areas. Where it occurs, keep activity concentrated in established areas.
- Consider limiting or removing livestock from low-snow wintering areas where they compete with elk, in order to mitigate for habitat losses occurring through developments on elk winter range in other areas.
- Carefully research elk use of particular areas before creating new human activity zones. Avoid creating new developments or disturbances in areas where elk have no alternative winter range to use or where impacts cannot be adequately mitigated.

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EFFECTS OF WINTER RECREATION ON GRAY WOLVES

POPULATION STATUS AND TREND

Gray wolves *(Canis lupus*) were once distributed throughout North America and were native to the Yellowstone area (Bangs and Fritts 1996). In the conterminous United States, they were extirpated to 3 percent of their historical range (Fuller et al. 1992). In the Greater Yellowstone Area (GYA), wolves were eliminated by the mid-1930s as a result of systematic predator control (Weaver 1978).

Following the approval of the 1994 environmental impact statement on the reintroduction of gray wolves into the Yellowstone and central Idaho ecosystems, wolves were reintroduced to these areas in 1995 and 1996 (USFWS 1994). Although wolves are classified as "endangered" in Montana, Idaho, and Wyoming under the Endangered Species Act of 1973 (USC 1531, 1982 amend.), they were reclassified as "experimental/non-essential populations" in the Yellowstone and central Idaho ecosystems before they were reintroduced to allow more flexibility in managing the species. This designation allows government agencies more options for relocating or removing individual wolves preying on livestock (USFWS 1994).

In 1995, 14 wolves were reintroduced into Yellowstone National Park using three "soft release" pen sites; 17 additional wolves were reintroduced to the park in 1996, and four pen sites were used (Phillips and Smith 1997). In January 1999, there were approximately 116 wolves in at least seven packs within the GYA (Bangs et al. In Press).

LIFE HISTORY

Wolves are highly social and hierarchical, and they live in family groups called packs. Packs consist of the dominant or "alpha" breeding pair, their recent litter of pups, and other adult and subadult individuals (Mech 1970, Tilt et al. 1987). During early spring (mid-March to early April), wolf packs excavate a den and rear a litter of pups. Average estimated birth date for wolf pups in the Yellowstone area in 1995 and 1996 was April 24 (Phillips and Smith 1997); pups are nursed six to eight weeks. At one to two years of age, a young wolf leaves the pack and tries to form its own pack.

Wolves depend upon ungulates for food. In the Yellowstone area, the primary prey for wolves is elk (87%); other prey includes moose, deer, antelope, and bison (Phillips and Smith 1997). Wolves prey on ungulates throughout the year (Tilt et al. 1987), and use ungulate carcasses (elk and bison) during early spring prior to denning. The peak period of availability of carcasses occurs about mid-April (Green et al. 1997; D. Smith, Yellowstone National Park, personal communication).

HABITAT

Wolves are not habitat specific and use much of the landscape within their pack's established territory (Mladenoff et al. 1995), however, snow depth and condition can influence wolf movements in the winter (Mech 1970, Paquet et al. In Press). Winter foraging occurs primarily on ungulate winter range. The ungulate winter range is also the key spring habitat for wolves as most winter-killed carcasses are found here.

HUMAN ACTIVITIES

Winter recreation has the potential to affect gray wolf movements and habitat use during the period of winter foraging and early spring denning. In the GYA, winter foraging typically occurs on the following ungulate winter ranges: the Yellowstone northern range (Mack and Singer 1992), the North Fork of the Shoshone River, the Jackson Hole basin, the Clarks Fork River (Boyce and Galliard 1992), and the areas that are geothermally influenced within Yellowstone National Park (Green et al. 1997).

Some information exists on specific effects of winter recreation on gray wolves. Most information, however, is available from data on the effects of other human activities. Paquet et al. (In Press) found that winter movements of wolves in Canadian parks were influenced by human activities. Winter activities that compact snow cover, such as snowmobiling, cross-country skiing, and maintenance of winter roads, provided feasible travel routes for wolves into areas that were usually inaccessible because of deep snow (more than 15.5–19.5 inches). The consequences of this are that there may be modifications to wolf/prey interactions and habitat use as well as differences in landscape movements between groups of prey (Paquet et al. In Press).

Studies of snowmobile use and wolf movements in Voyagers National Park (NPS 1996) have shown that wolves tended to avoid areas of snowmobile activity in restricted-use areas. The studies also showed that repeated avoidance or displacement could result in permanent displacement, an impact to an animal's winter energy budget, and/or a conditioning of the animal to avoid certain areas. While the study did not prove that winter recreational use harmed wolves, it suggested that the National Park Service should close important wolf foraging areas to winter use until a better understanding of wolf–snowmobile interactions could be determined.

Other studies have documented similar responses by wolves in the avoidance of roads. In Kenai National Wildlife Refuge, radio-collared gray wolves avoided year-round access roads open to public use and were attracted to roads that were closed or were managed for limited human use. Wolves used low-use roads as travel corridors (Thurber et al. 1994). Wolf avoidance of settled areas and public roads in this study area was more a result of behavioral avoidance rather than direct mortality of animals. In Jasper National Park, wolves avoided traveled roads and were negatively affected by disturbance at den sites (Carbyn 1974). In Yellowstone National Park, wolves use areas near groomed snowmobile roads because there are ungulates wintering in the vicinity. On one occasion in 1997, wolves initially used an elk kill along a groomed snowmobile road and then left it when humans were present (D. Smith, Yellowstone National Park, personal communication).

Developments in Canada were shown to negatively affect wolves in Banff, Yoho, and Kootenay national parks. In Banff National Park, the town of Banff partially blocks natural wolf movement, denying access to prime habitat east of town (Purves et al. 1992).

POTENTIAL EFFECTS

Winter recreation has the potential to affect gray wolves during winter foraging and denning periods. Potential wolf/human conflicts could occur in winter foraging habitats, along snowmobile and ski trails, or near developments. The literature shows that wolves both used and avoided roads and trails designated for winter use. Although wolves use snowmobile trails for travel and foraging, they avoid roads, trails, and facilities if humans are present. The ecological significance of altering natural movement and foraging patterns is not fully known. Human activity during late winter/early spring could also displace wolves during the sensitive denning period.

Gray wolves in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Wolves may avoid habitats near winter developments when they occur on or near important ungulate winter ranges and when the developments remain open during spring denning periods (early to mid-April). This is especially critical when developments occur in or near high-quality winter and spring habitats that may include geothermally influenced winter range, low-elevation winter range, and other areas where winter-killed carcasses are found.

(2) Primary transportation routes and (3) scenic driving routes. Primary roads may affect wolf populations by fragmenting pack movement and causing direct mortalities. Five wolves were killed by vehicles in Yellowstone National Park between 1995 and 1997 (Gunther et al. 1998).

(4) Groomed motorized routes. Conflicts could occur when routes groomed for snowmobiles bisect habitats used by wolves in the winter, affecting wolf movements and foraging patterns. Moreover, grooming of roads and trails may affect ungulate movements (Meagher 1993), and this may influence wolf movements as well (Paquet et al. In Press). Areas of particular concern are ungulate concentration sites where winter-killed carcasses are available. These include both geothermally influenced and low-elevation winter ranges.

(6) Backcountry motorized areas. Wolf activity could be affected in ungroomed areas used by snowmobiles. Although areas of ungroomed snowmobile use typically occur at high elevations where wolves do not occupy winter habitats, there is potential for conflicts between wolves and recreationists if winter snowmobiling occurs on low-elevation or geothermally influenced ungulate winter range. Impacts would also occur if wolves were deliberately chased by recreationists on snowmobiles.

Management Guidelines

- New winter recreational developments should not be built near ungulate winter ranges or where they would impede wolf movements between high-quality habitats. Moreover, existing destination areas should be closed by April 1 to prevent the displacement of wolves during critical denning periods.
- By definition, year-round routes will remain open whether winter recreation occurs or not. Wildlife managers should immediately remove road-killed animals from roadsides to prevent foraging wolves from being hit by vehicles.
- New groomed motorized routes should be located in areas that are not classified as ungulate winter range or important wolf habitat. Grooming and use of snowmobile roads and trails should end between March 15 and April 1, allowing wolves to use spring denning sites without harassment. Human use of geothermally influenced winter ranges in the Firehole, Gibbon, and Norris areas of Yellowstone National Park should be managed during winter in a manner that allows wolves to forage; human use may cause displacement from these high quality habitats.

- Dispersed motorized use should not occur on or near ungulate winter range or on spring range after wolf denning begins, usually between March 15 and April 1.

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EFFECTS OF WINTER RECREATION ON GRIZZLY BEARS

POPULATION STATUS AND TREND

Historically, grizzly bears *(Ursus arctos horribilis)* ranged throughout most of western North America. Today, only a fraction of historic population levels occupy a remnant of their former distribution range (USFWS 1993). Loss or degradation of habitat in conjunction with unregulated hunting and livestock depredation control are cited as the main factors contributing to their decline (USFWS 1993). Grizzly bear populations have persisted only where large areas of public land maintained in a natural state provide necessary habitat components. Limited and/or regulated human activity has proven to be a requirement for the maintenance of grizzly populations (Mattson 1990). Today, there are six recovery zones designated within the conterminous United States (USFWS 1993). One of these zones includes a portion of the Greater Yellowstone Area (GYA), where a self-perpetuating grizzly bear population exists.

Under the authority of the Endangered Species Act (ESA), the U.S. Fish and Wildlife Service listed the grizzly bear as a threatened species in 1975. Recovery goals for the Yellowstone grizzly have since been established (USFWS 1993). However, the bear's long-term future remains uncertain and controversial. Threats to its existence are numerous (Picton et al. 1985, Mattson and Reid 1991, Eberhardt et al. 1994, Eberhardt and Knight 1996). In addition, determining population size and the characteristics used as a basis for trend predictions have been problematic (Schullery 1992, Eberhardt et al. 1994, Eberhardt and Knight 1996).

The grizzly bear population declined in the early 1970s following the closure of open garbage dumps and subsequent human-caused mortality around the GYA. Since then, trend data indicate a modest population increase (Eberhardt and Knight 1996). While grizzly bear mortalities, including human-caused deaths, have varied widely in the GYA during the past decade, cub production has increased (Eberhardt et al. 1994, Eberhardt and Knight 1996). A turning point in the earlier trend came in the mid-1980s when government agencies committed substantial resources toward the goal of preventing adult female grizzly bear mortality and protecting important grizzly bear habitat (Eberhardt et al. 1994, Gunther 1996).

Human-caused mortality of grizzlies, especially females, continues to be of particular concern in the recovery of this species; direct human-caused mortality is the cause of virtually all grizzly bear population declines and extinctions (Mattson 1993). There are several factors that complicate efforts to deal with this issue. It is impossible to predict the number of bear mortalities that will occur in a given time frame, and the range of variation from year to year can be large. Although the grizzly population may be increasing, human use of the GYA is also increasing. This means the potential for bear–human conflicts and human-caused mortalities persist and will probably grow.

Numerous researchers have analyzed grizzly bear mortality data for the GYA (Povilitis 1987, Craighead et al. 1988, Knight et al. 1988, NPS 1988). Their findings indicate that most grizzly bear mortalities since 1974 involve humans and can be classified as either illegal shootings or management-control actions. Povilitis (1987) found that almost half of the mortality risk was associated with people carrying firearms on national forest lands. Within Yellowstone National Park, almost all grizzly bear mortalities were the result of management actions by the National Park Service against habituated, human-food-conditioned grizzlies (Gunther 1994).

Knight et al. (1988) reported that known and probable deaths of grizzly bears tend to be centered around specific areas in and around Yellowstone National Park. They described these as "population sinks" and identified them as the gateway communities surrounding Yellowstone National Park, major development areas within the park, sheep grazing allotments, and various other human concentration areas.

One of the major problems associated with human development in occupied bear habitat is the availability of attractants (garbage and human and pet food). Human garbage is cited as one of the major contributors to bear conflicts with humans (Herrero 1985). If food is obtained at one of these sites by a bear, the bear may periodically check the site for more food. The bears that are thus conditioned are often the target of management actions and usually become mortalities.

Bears are also killed by illegal shooting. These shootings may be categorized as self-defense, defense of property, hunters mistaking grizzlies for black bears, and poaching. An increase in people in areas where there are bears increases the likelihood of mortalities by shooting. There are other issues to consider in the long-term status of the Yellowstone grizzly bear. The population may reach carrying capacity, causing a decrease in subadult survival (Eberhardt and Knight 1996). Available food may be reduced by climatic change (Picton et al. 1985, Mattson and Reid 1991), loss of whitebark pine from blister rust infection (Kendall and Arno 1990, Mattson and Reid 1991), and a decrease in Yellowstone cutthroat trout as a result of whirling disease and competition with lake trout (Varley and Schullery 1995).

Life History

Much is known about the life history of the Yellowstone grizzly bear (McNamee 1984). However, only those details that relate to the topic of winter recreation use will be mentioned here. Cubs are born in the den from late January to early February. They are helpless and rely on the mother for warmth and nourishment. The average litter size is about two (Schullery 1992). This is a time when both mother and offspring are especially vulnerable (Reynolds and Hetchel 1980).

Habitat

Denning

In a five-year study of Yellowstone grizzly bears in the late 1970s, November 9 was found to be the mean entrance date for 70 bears tracked to their dens. The earliest entrance date recorded was September 28 for a pregnant female and the latest was December 21. Pregnant females entered dens earliest, but differences in the mean denning dates of sex and age groups other than pregnant females were not significant. Bears frequented the immediate area of den sites from 8 to 22 days before entering (Judd et al. 1986).

Male grizzlies were usually the first to leave their dens, emerging between mid-February and late March. The other population segments generally emerged in the following order: single females and those with yearlings and two-year-olds followed by females with new cubs. The last group emerged between early and mid-April (Judd et al. 1986).

Judd et al. (1986) concluded that bears did not seek den sites in open areas or show strong preference for a specific type of canopy coverage; however, sites with whitebark pine and subalpine fir appeared to be preferred for dens. Both tree species are found at higher elevations. Elevation of dens ranged from 6,500 to

10,000 feet; and the average elevation was 8,100 feet, with an apparent clumping in the range of 8,000 to 9,000 feet.

Dens were found on all aspects, but there was an apparent preference for north exposures. Most dens were found in the 30 to 60 degree slope range. Some dens were reused, but others collapsed after a season of use (Judd et al. 1986).

Judd et al. (1986) concluded that availability of denning sites did not appear to be a critical element of grizzly bear habitat in the Yellowstone area since grizzly bears appear to be able to use sites with a wide range of environmental characteristics. In addition, given the amount of protected habitat in Yellowstone National Park and the surrounding national forest wilderness areas as well as the large size of a grizzly bear's home range, they did not think den sites would become scarce in the foreseeable future.

Denning studies in Canada, Alaska, and the Northern Continental Divide Ecosystem (IGBC 1987) indicate that while there are differences in entry and emergence dates, there is commonality in the data on den characteristics. These data also indicate the adaptability of grizzly bears in den site selection and a strong fidelity to denning areas. Although den re-use has been documented in many areas, it is not considered common; however, returning to a denning area is. These denning areas apparently possess characteristics that make them favorable, and some individuals remain traditional in using them (IGBC 1987).

PRE-DENNING AND POST-EMERGENCE

The activity of grizzly bears before denning and after emergence follows a predictable pattern that is determined by feeding behavior. The food habitats of Yellowstone grizzly bears are summarized in Knight et al. (1984) and Mattson et al. (1991). These investigations show that grizzly bears are opportunistic feeders that use a wide variety of animal and vegetal food items. Although diet varies as much by season as by month, trends are discernible. The main items in the diet of Yellowstone grizzly bears are whitebark pine nuts and ungulates. Grizzly bears obtain a substantial portion of their energy from ungulates in the spring (Mattson 1997). This food source is estimated to be one of the top two sources of energy in the average diet, especially during March, April, May, September, and October (Knight et al. 1984). Carrion scavenged from March through May constitutes a major portion of this ingested meat (Mattson et al. 1991), with peak availability of carcasses occurring around mid-April (Green 1994, Green et al. 1997).

In fall, bears aggressively forage to store fat for winter. This pursuit is called hyperphagia and is characterized by a determined attempt to increase calorie intake. The most important fall diet item for Yellowstone grizzly bears are whitebark pine seeds. Because the need for food is so intense, bears may approach areas of human activity that they would ordinarily avoid during this time when whitebark pine seeds are not available (Mattson 1990, Mattson et al. 1992).

In spring, bears leave their denning sites at higher elevations and search for carrion from winter-killed bison and elk. Therefore, key spring habitats for Yellowstone grizzly bears are ungulate winter ranges (Mattson 1997). Bear use of ungulate carcasses during spring varies among habitats. Green (1994) found that grizzly bear use of spring carcasses increased with elevation and that bears were more likely to use carcasses in the geothermally influenced habitats of the Firehole–Gibbon and Heart Lake areas than in the low-elevation areas of the Yellowstone northern range. This occurred even though most spring carrion in Yellowstone National Park was found on lower elevation ungulate winter range (Green 1994, Mattson 1997, Green et al. 1997).

Various studies have indicated that live ungulates are used as food when they are most available and vulnerable, as weakened animals during the spring (Henry and Mattson 1988, Green et al. 1997), as calves during May and June (Gunther and Renkin 1990), or as weakened bulls during the fall rut (Schleyer 1983). A few grizzlies have learned to kill adult elk during the summer (Servheen and Knight 1993).

Another high-energy diet item for Yellowstone grizzly bears following den emergence is whitebark pine seeds. Whitebark pine seeds are an energy-rich bear food typically found at higher elevation forest stands during the fall (Mattson and Reinhart 1994). However, after a high whitebark pine cone crop, cones will remain available during the following spring. As a result, bears will forage in these higher-elevation habitats, apparently preferring this food item to carrion (Mattson 1997, Green et al. 1997).

HUMAN ACTIVITIES

Judd et al. (1986) acknowledged that a deficiency in their investigation of grizzly bear denning activity in the GYA was the lack of insights gained on the impact of humans to bears during this period in their lives. The den sites they investigated were remote from humans at all times of the year, and there was no opportunity to address this issue.

One of the few studies that did deal with this topic was conducted in Alaska. It considered the impact of winter seismic surveys and small fixed-wing aircraft on denning grizzly bears (Reynolds et al. 1984). Grizzly bears used in the study were radio-collared or had heart-rate transmitters implanted. Potential sources of disturbance included the sounds of aircraft, sounds of operating vehicles (track-mounted drill rigs, geo-phone trucks, survey Bombardiers, snow machines, support trains), and sounds of shock waves associated with the detonation of about 85 pounds of dynamite at approximately 100 feet below the surface.

Detonations conducted within a range of 0.8 to 1.2 miles of the bears did not cause them to leave the den. However, movements within dens were sometimes detected following blasts (Reynolds et al. 1984). When seismic vehicles passed within 5/8 mile of the den, the bear's heart rate was elevated much more often than when undisturbed (Reynolds et al. 1984). Circumstantial evidence indicated that an unmarked bear left its den when seismic activity was within 650 feet of the den, but tractors and tracked vehicles came within 325 feet of a denned female with 3 yearlings without causing den abandonment. Mid-winter over-flights of dens with small fixed-wing aircraft did not change the heart rates of two females denning with young; however, flights conducted closer to the time of den emergence did change the heart rates of bears. The authors concluded that even if animals did respond to noises associated with seismic exploration activities, effects on them were probably minimal at these distances and at this level of activity (Reynolds et al. 1984). None of the radio-collared bears deserted dens, and there was no evidence of mortality.

Other research shows varying effects of human use on hibernating bears. Harding and Nagy (1980) documented grizzlies successfully denning on Richards Island, Northwest Territories, in the general area of hydrocarbon mining activity. Of the 35 dens they located, 28 were within the potential impact area, including several within one to four miles of active mine areas. However, Goodrich and Berger (1994) demonstrated that black bears abandoned den sites in response to disturbance.

Reynolds and Hechtel (1980) speculated that agitation within the den could have serious consequences for females with newborn cubs. Watts and Jonkel (1989) supported this idea and added that the ability of bears to reduce energy output in the winter may be a function of the secure den environment. In addition, human disturbance during denning could accelerate starvation and has resulted in den abandonment. They concluded that poor quality den sites and adverse weather could elevate metabolic rates and increase energy demands. Also, Geist (1978) discussed the implications of energy expenditure for animals and noted that when they are excited, the energetic costs from increased metabolism and heart rate can be significant. Presumably, this would hold true for bears in a den.

By their nature, dens represent locations where bears concentrate activities. This raises the concern of bear–human conflicts around dens. However, there are few documented cases of people being injured by bears in the vicinity of den sites. Herrero (1985) concluded this type of behavior may be due, in part, to the fact that dens are consistently in remote areas less traveled by people.

To a greater extent, grizzly bears may be affected by human activity while foraging during the pre- and post-denning periods. The pre-denning and post-emergence periods are critical times for bears. In the first time frame, they are in an intense feeding mode to store fat for the winter, and in the second time frame they are in search of food after depleting their reserves over the winter.

POTENTIAL EFFECTS

The literature indicates that bears can be impacted by human activities in winter. There are three stages in the annual cycle of the grizzly bear when it is vulnerable to the impacts of winter recreation use: (1) pre-denning, (2) denning, and (3) post-den emergence. Because of this, it is important to address a longer time frame than the traditional winter months. For example, the pre- and post-denning periods for bears overlap the fall and spring seasons, respectively. Therefore, it is reasonable to consider the pre- and post-denning time for bears as biological events instead of restricting an analysis of effects to calendar dates.

By the nature of how some recreational facilities are managed, winter visitor use generates effects on grizzly bears in the fall and spring that would otherwise not occur. The existence of winter-use facilities and programs likely encourage additional public visitation in the shoulder seasons. Winter recreational effects on bears are thus contingent on when and where facilities open in the fall and close in the spring.

Destruction of den sites or denning habitat does not appear to be a major issue in the GYA at present or in the near future. Neither does disturbing bears while they are preparing or occupying dens, although the possibility exists. The main concern is the potential for bear–human conflicts and displacement of bears while they are foraging during the pre-denning and post-emergence periods. Specifically, this involves bears engaged in wide-ranging foraging efforts before denning, mainly near whitebark pine habitats. It also includes the use of ungulate wintering areas by bears seeking carrion after leaving dens, and, to a lesser degree, bears using over-wintered whitebark pine seed crops at higher elevations.

Grizzly bears of the GYA may be affected by human winter recreation use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact grizzly bears. This

is primarily in the context of the pre- and post-denning periods. For example, spring surveys of grizzly bear habitats have shown that bears generally used carcasses less often than expected within 3 miles of a major park development (Green et al. 1997). Moreover, when bears come in proximity to park developments, more bear management actions and subsequently more grizzly bear removals occur (Mattson 1990, Reinhart and Mattson 1990).

Winter destination areas are becoming more popular. They include major ski areas, resorts, developments in Yellowstone National Park, and park gateway communities. These areas have been historic population sinks for grizzly bears in the GYA (Knight et al. 1988). The potential for bear–human conflicts is high when winter developments remain open after bears emerge from hibernation and are using spring habitats (approximately March 15) (Green et al. 1997). This is especially critical when these developments occur in or near areas where winter-killed ungulates and over-wintered pine nut crops may be found (Mattson et al. 1992).

In addition, bears will seek attractants around human developments in the pre-denning period of hyperphagia when food is less available. Frequently, the result is bear–human conflicts. Mattson et al. (1992) concluded there is a relationship between the quality of the fall pine nut crop and the number of conflicts that occur. During years of widespread pine nut use, grizzly bears are seldom found in proximity to human facilities. However, during years of little or no pine nut use, areas near human facilities (less than 3 miles from roads and 5 miles from developments) were used intensively by bears. Also, managers trapped nearly six times as many bears and nearly two times as many bears were killed during years of low pine nut production. Presumably, this was a consequence of bears being nearer and in more frequent contact with humans while seeking alternate foods to compensate for the lack of available pine nuts.

(2) Primary transportation routes and (3) scenic driving routes. Year-round roads will exist regardless of winter recreation use. However, winter recreational use management may cause changes in the amount of traffic a road receives. It may also be a catalyst for creating new roads.

Winter vehicle use of year-round roads during the denning period does not pose a risk to bears. Bears and traffic are spatially separated during most of the winter, and bear behavior seldom brings them into contact with the road corridor. Bear attractants along roads in the pre- and post-denning periods do present a risk. This could occur at roadside trash collection sites or as deliberate feeding of panhandling bears. An additional concern is road-killed animals (usually ungulates or rodents) that may attract bears to the roadside where they are vulnerable to vehicle collision.

(4) Groomed motorized routes and (5) motorized routes. Snowmobile traffic alone on highly and moderately groomed routes does not present a significant impact to bears during

most of the winter months. This is because of the predictability of defined snowmobile corridors and because most snowmobile use occurs during the time that bears are in hibernation. Conflict could occur when snowmobile use coincides with spring bear emergence and foraging. The potential for bear–human conflicts in Yellowstone National Park during the spring emergence is exacerbated by the fact that park roads are often located near thermal areas where ungulates congregate in the winter. The geothermally influenced ungulate winter ranges in the Firehole, Gibbon, and Norris areas are good examples of locations where the risk of bear–human conflict in the spring is high.

(6) Backcountry motorized areas. Most use of ungroomed snowmobile areas should not conflict with bear activity because it coincides with bear hibernation. Moreover, areas of ungroomed snowmobile use typically occur at elevations above bear spring habitats. An exception is when overwintered whitebark pine crops are available, and bears forage at high elevations in the spring. Another possible effect may occur because most backcountry snowmobile use occurs at higher elevations, where most bear denning is found.

The potential for conflicts between bears and recreational users does exist when dispersed use occurs after bear emergence (between March 1 and March 15).

(7) Groomed nonmotorized routes. Skiing along groomed routes does not present a significant impact to bears during most of the winter months. This is because of the predictability of defined ski corridors and the timing of most skiing coincides with bear hibernation. Conflict could occur when skiing is at the same time as bear foraging in the post-den emergence period.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes does not present an impact to bears during most of the winter months. This is because of the timing of most of this travel coincident with bear hibernation. Conflict could occur when travel coincides with bear foraging in the post-den emergence period.

(9) Backcountry nonmotorized areas and (10) downhill sliding. Backcountry skiing, showshoeing, and downhill sliding should not present an impact to bears during most of the winter months. Again, the potential for bear–human conflicts may occur during the late winter period after bears emerge from hibernation. A component of this is the risk of human injury resulting from surprise encounters in backcountry areas as people disperse across the landscape in a manner unpredictable to bears (Herrero 1985). A unique expression of this occurs in low-elevation ungulate winter range where people search for dropped elk antlers. In this case, people intentionally canvas all parts of the terrain and concentrate on areas where wintering and winter-killed elk are found.

MANAGEMENT GUIDELINES

- (1) Destination areas. Early and mid-December and early and mid-March should be used as a time for transition from a fall to winter and winter to spring management strategy, respectively. Appropriate actions include closing facilities, restricting human use in sensitive areas, improving sanitation, and providing public education. Management of developments should reflect recognition of an increased potential each spring for bear–human conflicts and displacement of bears foraging within important habitats.

On public land, developments can be regulated, but it is more difficult to address activities at developments on private land. In these cases, coordinated sanitation programs involving private interests and government organizations are needed to remove attractants year-round, with a special emphasis placed on securing attractants during the pre-denning period.

- (2) Primary transportation routes and (3) scenic driving routes. Good roadside sanitation should be maintained. Signing to inform motorists of the need to secure attractants should be provided.

  Carcasses should be removed from the roadside between March 1 to November 30. No new roads to accommodate winter recreational use should be built in grizzly bear habitat as more access would ultimately result in more bear–human conflicts.
- (4) Groomed motorized routes and (5) motorized routes. Grooming and use of snowmobile roads and trails should end by March 15 in areas where post-denning bear activity is high.
- (6) Backcountry motorized areas. Where winter use occurs in ungulate wintering areas, activity should end by March 15. In areas with whitebark pine forests, a primary issue is the displacement of bears. Because the presence of over-wintered pine nut crops is not consistent, this is an episodic and not an annual concern. Therefore, travel restrictions should be addressed based on yearly monitoring rather than as a continuous restriction.
- (7) Groomed nonmotorized routes. Depending on the observed risk, grooming and use of these routes should end between March 1 and March 15 in those areas where bears would potentially be drawn to forage. Sanitation procedures around associated support facilities should be strengthened and public education initiated during the same time frame.
- (8) Nonmotorized routes. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.
- (9) Backcountry nonmotorized areas and (10) downhill sliding. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.

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LYNX: THEIR ECOLOGY AND BIOLOGY AND HOW WINTER RECREATION EFFECTS THEM

POPULATION STATUS

Lynx *(Lynx canadensis)* historically occupied much of the northern portion of North America, but the loss and degradation of their habitat and the unregulated hunting and trapping that accompanied European settlement reduced their numbers and distribution in the conterminous United States (Jackson 1961, Ruediger 1994). Today, remnant lynx populations persist in some high-elevation boreal forests of the western and Great Lakes states, tied chiefly to the distribution and abundance of snowshoe hares (*Lepus americanus*) (Koehler and Aubrey 1994).

In 1999, the U.S. Fish and Wildlife Service (USFWS) is expected to list the lynx as a threatened species under the authority of the Endangered Species Act (ESA). The listing will culminate a series of actions that included a petition by conservation groups to list the species in 1992 and a series of court decisions. The action will require development of a recovery plan by the USFWS and also require that actions taken by federal wildlife and land-management agencies do not jeopardize the species' welfare. Lynx are already treated as a sensitive species by most federal and state wildlife management agencies in the western United States.

Montana is the only state in the contiguous United States that still allows trapping of lynx. There is currently a statewide quota of two lynx, with a limit of one per trapper per year. Trapper harvest peaked at 60 in 1979 but was reduced to two lynx per year by legislation. Trapper effort has also declined in spite of high lynx fur prices in the 1980s. Illegal and incidental harvest are thought to be negligible (Giddings et al. 1998).

Forest management practices and development of roads and human facilities may adversely affect lynx. However, the rarity and secretiveness of this species make its distribution and habitat requirements difficult to document (Ruediger 1994). The purpose of this report is to review and synthesize current literature on the effects of winter recreation on lynx within the Greater Yellowstone Area (GYA).

THE ABUNDANCE AND DISTRIBUTION OF LYNX IN YELLOWSTONE NATIONAL PARK

Although reliable information concerning the abundance and distribution of lynx is lacking, historical information suggests that this species was present but uncommon in Yellowstone National Park (YNP) from 1880 to 1980. This condition also describes the status of lynx in YNP today. Lynx were listed among animals that were present and seen by naturalists as early as the 1870s (Grinnell 1876, Blackburn 1879). Consolo Murphy and Meagher (In Press) documented the presence and distribution of lynx in YNP from 1893 to 1995 using sighting records, photographic records, and museum collections. They located 1 museum specimen of a female lynx, 34 sighting reports (39 total lynx), 17 observations of tracks, and 6 other forms of supportive evidence (*e.g.*, photographs). Lynx or their sign were observed parkwide, but visual observations were more common in the southern half of the park and tracks were more common in the north. Most (n=50) sightings and records of tracks occurred after 1930. Consolo Murphy and Meagher (In Press) included a reference to a hide from an illegally trapped lynx that was confiscated by park rangers near Norris Geyser Basin (Harris 1887). In addition to these records, 1 lynx was reported seen and 6 sets of lynx tracks were found in 1887 by T. Hofer, a pioneering naturalist and early visitor to the park (see *Field and Stream* 1887, April 7 to May 5 issues). Hofer's observations occurred at Norris Geyser Basin (tracks), Lower and Midway Geyser basins (tracks), Shoshone Lake (sighting), Alum Creek (tracks), and Canyon (tracks). *Yellowstone Nature Notes*, an in-house periodical of natural history observations made by YNP personnel, also contains 5 records of direct observations of lynx (7 total animals) spanning 1928 to 1958 that were not reported by Consolo Murphy and Meagher. More recently, Halfpenny (unpublished data) identified 1 set of lynx tracks near Snake Hot Springs in February 1979. From 1995 to present, 5 sightings of lynx were reported in YNP, 3 on the northern range and 2 in the park interior (K. A. Gunther, Yellowstone National Park, personal communication).

Unfortunately, records of lynx sightings or their tracks carry caveats with regard to reliability. YNP records prior to 1980 typically contained insufficient information to determine observer credibility and to estimate weather and lighting conditions. Consequently, misidentified animals may be represented in the data. In particular, inexperienced observers may easily confuse bobcats (*Lynx rufus*) with lynx.

Numerous researchers have attempted to document the presence of rare carnivores in YNP during this decade. Murphy (unpublished data) found no lynx sign while searching 7,500 km of transect on the northern winter range and vicinity from the winters 1987–88 to 1991–92 incident to cougar studies. No lynx were detected by Harter et al. (1993), who deployed 11 hair snares (387 trap nights) and 21 remote cameras (102 nights), and searched 16 track transects (116 km) on the northern winter range and vicinity from January to March 1993. Similarly, no lynx were found by Gehman et al. (1994), who deployed 20 hair snares (1,609 nights), 12 cameras (961 nights), and 31 track transects (200 km) from December 1993 to February 1994 on the northern winter range and vicinity. Finally, Gehman and Robinson (1998) did not detect lynx when they deployed 4 cameras (4 sites; approx. 138 nights) and 14 transects (80 total km) along the upper Gallatin River in YNP (see below for their sighting of a probable lynx track 10 km northwest of YNP).

The Presence and Distribution of Lynx in the GYA

Museum, trapping, and other agency records indicate lynx distribution in the GYA prior to 1976 (Giddings et al. 1998; Fig. 1) with approximately 107, 6, and 8 occurrences of lynx in Wyoming, Montana, and Idaho, respectively (our counts from Giddings et al. 1998), including 8 records for Grand Teton National Park (GTNP). These records do not include a lynx killed in 1920 by ranger and his hounds in the Hellroaring Creek drainage (Stevenson 1920). In the GYA from 1976 to 1993, there are 122, 19, and 13 occurrences of lynx in Wyoming, Montana, and Idaho, respectively, including four records in GTNP. Lynx reports occur for the Absaroka, Beartooth, Centennial, Gallatin, Gros Ventre, Madison, Teton, Wind River, and Wyoming mountain ranges as well as forested portions of eastern Idaho (Giddings et al. 1998).

Laurion and Oakleaf (1998) surveyed 2,055 km of roads and 2,400 km of backcountry trails in 12 areas on the Shoshone (SNF) and Bridger–Teton (BTNF) national forests in western Wyoming during winter 1997–98. Lynx tracks were identified in three locales (four total track observations) on the SNF and one locale (two track observations) on the BTNF. In addition, D. Stevenson (1997) surveyed nine snow-covered transects 29 times (269 total km) near Bridger Lake, BTNF, from February to March 1997, but found no lynx sign. S. Patlas (Wyoming Game and Fish Department, personal communication) surveyed a total of 169 km of transect at nine locales in northern GTNP and vicinity but found no sign of lynx. However, citizen observers have recently seen lynx or their tracks near Big Piney, Kemmerer, Moose, and Dubois, in the Upper Greys River watershed, Wyoming (Laurion and Oakleaf 1998).

An adult male and a female lynx were captured in the Wyoming Range near Merna, Wyoming in 1996–97 as part of a research project being conducted by Wyoming Game and Fish Department (see Laurion and Oakleaf 1998). A total of five to seven lynx resided on the study area, including the radio-marked individuals. The radio-marked female produced four kittens during May 1998.

In Montana, Gehman and Robinson (1998) surveyed 12 snow-covered transects 39 times (170 total km) and deployed cameras at 15 different sites in the Gallatin National Forest in 1997–98. They identified a probable lynx track in Buck Creek, a tributary of the Gallatin River.

LIFE HISTORY

The breeding season for lynx spans March to May. Kittens are born in May or June after a 60- to 74-day gestation period. Young are born without teeth, but with closed eyes, folded ears, and a well-developed pelage. Lynx walk by age 24–30 days and are weaned at 3–6 months. However, kittens may consume meat as part of their diet by an age of 30 days. Kittens typically remain with their mothers until about age ten months, but the period of maternal care may extend into the next mating season. Females can breed at age ten months, but usually do not until 22 months.

Natural predators of lynx include coyotes *(Canis latrans)*, wolves *(Canis lupis)* (Banfield 1974), cougars *(Felis concolor)* (Koehler et al. 1979), wolverines *(Gulo gulo)*, and lynx themselves (Elsey 1954). Lynx contract rabies and distemper, but these diseases do not significantly affect their population dynamics. Dominant mortality factors are malnutrition and starvation of kittens (Brainerd 1985). Malnutrition may dispose lynx to disease and parasites (Quinn and Parker 1987).

SOCIAL ORGANIZATION AND SPACING PATTERNS

Lynx are solitary carnivores, remaining apart except when mating. Mothers support their altricial young without direct support of fathers. Spatial and temporal separation results from social intolerance and mutual avoidance that is accomplished through scent marking. Intersexual overlap for territories is high. During lows in hare numbers, adults of the same sex are mutually hostile, maintaining exclusive territories (Berrie 1973, Mech 1980). In a Washington study, strong territoriality may have resulted from a varied and relatively stable prey base (Koehler 1990a). As hare populations increase, social intolerance among lynx breaks down, prompting increases in the degree of range overlap (Slough and Mowat 1996). When hares are extremely scarce, lynx may become nomadic or emigrate.

Home range sizes differ by sex, prey density, and other factors. Females typically have home ranges that are smaller than males, varying from 10–243 km^2, but normally 15–20 km^2 in size. Home ranges varied from 36–122 km^2 for males in Montana (Koehler et al. 1979, Brainerd 1985). In Wyoming, a male's range was 131 km^2 and a female's was 137 km^2

(Laurion and Oakleaf 1998). In Alaska and Canada, home ranges may exceed 40–80 km^2 when hare populations decrease. Large ranges may indicate prey scarcity (Hatler 1988). Inverse relationships between hare numbers and the size of lynx ranges are documented (Brand et al. 1976, Ward and Krebs 1985, Poole 1993). Home ranges may be abandoned at a threshold of low hare densities, prompting lynx to turn nomadic (Ward 1985, Ward and Krebs 1985). The relatively large sizes of lynx home ranges in the Rocky Mountains suggests that the availability of snowshoe hares is low.

Lynx typically achieve densities of one per 15–25 km^2. In Washington, density was one per 40 km^2 (Koehler 1990a). Home range sizes and densities of lynx exhibit regional and local variation that depend on topography and food availability. When hare populations are low, lynx may concentrate in pockets of high hare density, leading to density estimates that are not representative for landscapes at a broad scale (Koehler and Aubrey 1994).

POPULATION DYNAMICS

Lynx generally occur at low density and are associated with boreal forest habitats. Their population dynamics are characterized by low reproductive rates and are strongly related to population dynamics of snowshoe hare, a keystone species that is the primary prey of lynx. In Canada, lynx populations fluctuate roughly on a ten-year cycle, lagging behind a similar cycle for snowshoe hares (Elton and Nicholson 1942, Keith 1963). While hare densities may change 200-fold, those of lynx change only up to 20-fold. One explanation is that lynx numbers are tied to a poorly understood interaction between hares and vegetation, with regional synchrony tied to weather effects.

Cycles may be muted or absent near the southern limits of the lynx's distribution (*i.e.*, in the conterminous U.S.), where hare populations apparently are more stable than those in Canada (Dolbeer and Clark 1975), possibly owing to greater diversity and stability in hare predators and competitors and the absence of adequate habitat during periods of hare lows. Snow-tracking surveys for hares in Montana showed a three-fold change in numbers of hare tracks from 1990 to 1998; lynx tracks varied eight-fold (Giddings et al. 1998). Consequently, dramatic differences in reproduction, habitat use, prey selection, dispersal, and vulnerability may exist between lynx populations in Canada and the conterminous U.S.

When hare populations crash, lynx may emigrate great distances, potentially making treks from Canada to the GYA. Dramatic increases in lynx numbers occurred in western Montana following peaks in the Canadian population during 1962–63 and 1971–72 (Hoffmann et al. 1969, Koehler and Aubrey 1994). Following the hare crash of the early 1970s, lynx populations apparently increased in Wyoming as suggested by the high trapper harvest in the Wyoming Range (Laurion and Oakleaf 1998). Immigrating lynx have large home ranges and little reproductive success. When hares are scarce, lynx may also concentrate in small areas making them vulnerable to human-caused mortality (Koehler and Aubrey 1994). Consequently, rapid declines in populations occur. For example, Minnesota trappers harvested 215 lynx in 1972, 691 in 1973, 88 in 1974, and 0 in 1975 (Mech 1980). Recovery from trapping exploitation may be slow when lynx are at low numbers (Laurion and Oakleaf 1998).

Lynx are characterized by fluctuating reproductive rates that are driven by food limitation. Females may not reproduce at all during food shortages. In Montana, pregnancy rates of adult females reached 90 percent, but declined to 33 percent when food was scarce (Giddings 1994). Litters of adult females averaged 3.2 kittens and those of yearlings averaged 1.7 (Brainerd 1985) or 2.7 (Giddings 1994). In the GYA, one female had four kittens (Laurion and Oakleaf 1998). In general, population dynamics of lynx are affected more by failure to produce litters than the size of litters.

Food availability directly correlates with the survival of young lynx. Few kittens survive when food is scarce, with the result that recruitment of offspring to the breeding population is low to non-existent (Koehler 1990a). In the Wyoming Range, Laurion and Oakleaf (1998) found that few kittens survived through the summer.

Lynx may disperse long distances from their natal area. Dispersal distances for females range from 103–250 km and from 164–1,100 km for males (Slough and Mowat 1996). One female from Montana moved 325 km to British Columbia (Brainerd 1985). Previously territorial adults may become transient if prey bases become reduced. Most dispersers are young animals in search of unoccupied territories.

FOOD HABITS

Snowshoe hares constitute the main portion of the lynx's diet, about 60 percent in winter and 40 percent in summer. Other prey include squirrels (*Tamiasciurus hudsonicus*), voles (*Clethrionomys* spp. and *Microtus* spp.), mice (*Peromyscus* spp.), grouse (*Bonasa* spp. and *Dendragapus* spp.), ptarmigan (*Lagopus* spp.), and other birds. While not important predators of ungulates, lynx occasionally may kill adult deer (*Odocoileus* spp.) and moose (*Alces alces*) in poor physical condition or when snow conditions are favorable for predation or when ungulate offspring are available. Although chiefly an obligate predator, lynx will scavenge carcasses and eat vegetation.

Lynx take a variety of mammals when hares are scarce, but only hares support high population densities of lynx (Koehler 1990b). Kill rates average about two hares per three days, but rates vary with prey density. Food consumption may be 37 percent lower when hares are scarce (Brand et al. 1976). Food caching has been reported, particularly when prey is scarce.

HABITAT REQUIREMENTS

In Wyoming, lynx occur primarily in spruce-fir and lodgepole pine forests that slope at 8–12° at elevations between 2,437 and 2,937 m. For denning, lynx often select mature stands (250 years or older) of Engelmann spruce (*Picea engelmanni*), subalpine fir (*Abies bifolia*), and lodgepole pine (*Pinus contorta*) on north or northeast slopes and prefer sites larger than 30 acres in size with more than 80 downed logs (>20 inches diam.) per acre on north or east aspects. Old-growth spruce forests that have escaped natural fires in landscapes that are otherwise dominated by lodgepole pine also provide ideal denning habitat. Denning habitat is enhanced if forest parcels contain numerous alternate den sites and/or they are connected to other denning habitats (Koehler and Aubrey 1994, Tanimoto 1998). Dens are often located in hollow logs or in brush piles, particularly where surrounded by dense thickets. Downed logs 40–50 m in length provide escape cover for young kittens (Koehler 1990a, Koehler and Brittell 1990). Security cover is also necessary for diurnal rest areas used by adults and kittens that no longer use dens. Diurnal bed sites frequently occur in thickets near game trails.

Lynx are specialized predators that hunt in habitats preferred by snowshoe hares. Hares require densely stocked stands of deciduous shrubs or young conifers (*e.g.*, lodgepole pine

<2.5 cm dbh) (Koehler and Brittel 1990) for forage, escapes routes, and thermal cover. Hare abundance is positively correlated with the density of cover at 1–3 m above ground or snow. Hare food is typically woody browse smaller than 4 mm in diameter that is less than 60 cm above the ground or snow. Stands that reach densities of 16,000 stems per ha are ideal (Keith et al. 1984). The structural attributes of vegetation needed by hares can be achieved in less than 20 years of growth and serial succession in the moist forests of Oregon and Washington. However, these conditions may not be achieved for 80 years or longer in the GYA.

Hares require a diversity of food items, foraging on birch (*Betula* sp.), poplar (*Populus* sp.), willow (*Salix* sp.), and conifers. Pines are preferred to spruce, and spruce is preferred to fir. Because the nutrient content and palatability of forage decreases with increasing stem diameter, hares must browse selectively, consuming about 300 g per day, and cannot compensate for low food quality by increasing their consumption. Aspen (*P. tremuloides*) stands and forest edges, as well as open grass meadows and edges with forests, may also support high numbers of hares and lynx. At the southern extent of lynx range, Colorado lynx were found near upper treeline in mature spruce-fir habitats where the forest and tundra edges provided food for hares (Halfpenny and Miller 1981; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991).

Hares feed on buds, young branches, and tips of older trees. Forage must be above the snow (hares do not excavate), but not out of reach. Heavy snowfall may bend small trees, increasing forage for hares (Koehler et al. 1979, Koehler 1990b, Koehler and Brittell 1990). Deer, elk, and moose often reduce browse available to hares at ground level, particularly where wintering ungulates concentrate in or near habitats used by hares (Olson 1957; Telfer 1972, 1974).

Lynx denning and hunting habitat must be connected by corridors providing cover for travel. Corridors used by lynx include tops of ridges and riparian zones with more than 30 percent canopy cover provided by subalpine fir, spruce, and lodgepole pine. Corridors should be at least 100 m in width and contain at least 300 stems per acre (Ruediger 1994). Lynx will cross narrower openings but will rarely hunt in them.

On a landscape scale, lynx habitat includes a mosaic of early seral stages that support snowshoe hare populations and late seral stages of dense old growth forest that is not heavily fragmented by logging, roads, reservoirs, train tracks, or other developments. Connectivity between lynx populations is critical. Dispersal corridors should be several miles wide with only narrow gaps. Large tracts of continuous coniferous forest are the most desirable for lynx travel and dispersal (Tanimoto 1998).

INTERSPECIFIC INTERACTIONS

Lynx may compete with canids, other felids, mustelids, and raptors for snowshoe hares and small mammals. Bobcat home ranges often exhibit elevational separation from those of lynx, which are better adapted to deep snow. Bobcats are thought to displace lynx where both felids are locally sympatric. However, lynx occasionally may kill bobcats (Giddings et al. 1998).

EFFECTS OF WINTER RECREATION ON LYNX

Winter recreation has cultural, economic, and social aspects that may affect lynx both directly and indirectly. With respect to winter recreation, direct effects are those that change the survival of individuals. Losses resulting from lynx trapping, non-target trapping, or accidental deaths (*e.g.*, hit by cars) are examples of direct effects. Losses or degradation of habitat through habitat destruction or disturbance are examples of indirect effects. Because both direct and indirect effects influence vital rates (*e.g.*, natality and survival), they may strongly influence the viability of lynx populations.

Because of the secretive nature of lynx and their habit of using deep-forest habitats, few ecological studies of lynx exist, let alone research on the effects of winter recreation. However, the paucity of data should not be construed as evidence that winter recreation has no adverse effects on this species.

DIRECT EFFECTS

Trapping seasons may significantly reduce the viability of lynx populations, particularly if lynx are few and/or key breeding individuals are removed. Currently, Montana is the only state in which lynx may be legally trapped, but very few are taken in the Montana portion of the GYA. In all states of the Yellowstone ecosystem, lynx may also be killed incidentally by bobcat trappers and hunters that are unable to distinguish the two felids when observed directly (Todd 1985, Bailey et al. 1986, Koehler and Aubrey 1994, Giddings et al. 1998). In addition, houndsmen may chase lynx with their dogs after mistaking lynx tracks for those of bobcats or cougar.

Roads and snowmobile trails are an important aspect of winter recreation because they provide people with their principal access to wildlands. The type, density, and distribution of roads and trails in lynx habitat affect the probability that trappers will locate lynx tracks and legally take them in traps. Roads also affect the rate at which lynx are killed, incidentally by trappers and/or illegally by hunters or houndsmen. Thompson (1987) noted that all known lynx sightings on Vail Mountain Ski Area, Colorado, were animals that were shot (n=1) or illegally trapped (n=2). Easy access to lynx habitat is particularly detrimental when pelt prices are high or recruitment of young lynx to the breeding population is low (Koehler and Aubrey 1994).

No road-killed lynx have been documented in the GYA, but losses of coyotes, wolves, cougars, and black and grizzly bears are well documented (Caslick and Caslick 1997, Gunther et al. 1998). During an attempted restoration of lynx in New York, 22 percent of introduced animals were killed by automobiles (Brocke et al. 1992, Weaver 1993).

Lynx behavior may predispose them to collisions with vehicles, especially when emigrating, hunting, or travelling (Weaver 1993). Road edges and train tracks support exposed forbs, grasses, and shrubs during winter; these locations are suited to foraging snowshoe hares, mice, voles, and other small mammals. Consequently, these sites are also excellent hunting areas for lynx (Koehler and Aubrey 1994). During winter, lynx frequently travel along roads where adequate cover is available on both shoulders (Koehler and Aubrey 1994).

INDIRECT EFFECTS

Humans alter the structure, biotic composition, and arrangement of habitat components that are essential to lynx. Winter recreation and its associated infrastructure reduces the amount of suitable habitat available to lynx and reduces the effectiveness of pristine habitat because human disturbance causes lynx to avoid habitats that are otherwise suitable.

Habitat Destruction.—Development of resort and other destination infrastructure for winter recreationists destroys and fragments lynx habitat. Human populations in the ten counties comprising the GYE increased 7.4 percent from 1980 to 1990, while the number of households increased 8.4 percent (Feigley 1993). Although only a fraction of this development occurred in habitats potentially used by lynx, road and housing development in expanding recreation-based communities such as West Yellowstone and Big Sky, Montana, and Old Faithful, Wyoming, could represent a significant cumulative loss of lynx habitat. In addition, the highways and improved roads that connect these communities also represent habitat losses because the improved surface, particularly for wide roads (>15 m), is essentially unusable by lynx except for aforementioned opportunities to travel or hunt along the road shoulder.

Loss of Habitat Effectiveness Resulting From Disturbance.—Human disturbance associated with recreational infrastructure and roads can reduce the effectiveness of habitat in supporting lynx, even if habitat is otherwise of high quality. Losses of habitat effectiveness can be adverse because disturbances preclude lynx from using habitat in an optimal manner. Lynx and other wildlife may avoid developments and roads because of the association with humans, particularly if they are unfamiliar with the sights, sounds, and smells that accompany human activity (Gutzwiller 1995).

The paucity of studies makes it difficult to assess the magnitude of disturbance and displacement associated with winter recreation. Year-round, ungulates that are not habituated to humans adjust their distribution and activity patterns to avoid human activity (Lyon 1979, Aune 1981, Rost and Bailey 1979, Edge et al. 1985, Kufeld et al. 1988, Cassirer et al. 1992, Caslick and Caslick 1997). Displacement, including den abandonment, is documented for black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) (Jonkel 1980, Goodrich and Berger 1994).

The search for cross-country and downhill skiing opportunities leads recreational skiers to prime lynx habitat. Downhill and cross-country ski development destroys and fragments lynx habitat and increases disturbance associated with human traffic, thereby reducing habitat security for lynx (Halfpenny and Miller 1981; Thompson 1987; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991; Halfpenny 1991). Development of winter ski areas may also increase disturbance of lynx in the off-season, as recreational use and maintenance activity will occur year-round.

Snowmobiling may be particularly adverse to lynx because: (1) this activity occurs when animals are frequently in poor condition due to the stresses of winter (Anderson 1995); (2) this activity may be dispersed on the landscape (*i.e.*, not confined to roads) on national forest lands outside of wilderness areas; (3) it may occur at night when lynx are usually active; (4) it is frequently accompanied by human disturbance and habitat loss associated with recreational infrastructure; and (5) this activity may alter the density and distribution of snowshoe hares, a favored prey item. In Ontario, Canada, snowmobile activity altered the mobility, distribution, and movements of hares (Neuman and Merriam 1972). Road plowing, grooming, and construction activities that support snowmobilers may also significantly reduce the effectiveness of winter lynx habitats. In this regard, road density and the level of automobile use are important considerations because they affect the frequency and intensity of disturbance.

Disturbance, however, does not necessarily lead to a continued reduction in habitat effectiveness for lynx. With repeated exposure to human activity that is predictable in time and space, lynx may adapt behaviorally or physiologically (Bowles 1995). Lynx visited Geneva Basin and Vail Ski areas in Colorado at night to scavenge at garbage dumps (Halfpenny et al. 1982; Thompson 1987; Thompson and Halfpenny 1989, 1991). Lynx also used ski runs at Vail from adjacent non-developed habitat, despite night grooming operations (Thompson and Halfpenny 1989, 1991). Lynx also visited a night-active winter construction camp on the Frying Pan River in Colorado, presumably scrounging for garbage (J. Halfpenny, unpublished data).

Non-motorized recreational activities, such as backcountry cross-country skiing or snowshoeing, may affect lynx, particularly because the disturbance associated with these activities is often dispersed and unpredictable to mammals. Surprisingly, disturbance by people may have a greater negative effect than motorized vehicles on established roadways because mammals habituate more quickly to mechanical noise than to noises of humans (Schultz and Bailey 1978, Aune 1981, Cassirer et al. 1992, Gabrielsen and Smith 1995). Laughing and yelling can arouse responses of mammals at greater distances than snowmobile noise (Bowles 1995).

The cumulative impacts of dispersed winter recreation must also be considered. For example, the adverse effects of motorized recreation in one habitat may be additive to adverse effects of housing infrastructure elsewhere in an ecosystem. Consequently, the potential effects of all recreational activity should be considered together in cases where a single lynx population or a lynx metapopulation is present. In Colorado, the development of three potential ski areas (Wolf Creek Pass, Wolf Creek, and East Fork of the San Juan) in lynx habitat could have resulted in habitat destruction and alteration at each site, as well as reduced habitat suitability within the triangle among ski areas because of increased access and habitat size reduction (Halfpenny 1991).

One other relationship between winter recreation and lynx deserves consideration: the cumulative effect of human activity on the survival of lynx and their population viability during periods when hare populations are low. Stresses associated with winter recreation might force lynx across a mortality or reproductive threshold, leading to population declines and extirpation of local populations. As previously mentioned, female lynx fail to produce litters or have reduced litter sizes during periods of food limitation. Kittens may also frequently die of malnutrition during winter due to the stresses incurred during this season. Thus, reduced recruitment of breeding individuals during periods of hare shortages contributes directly to dramatic declines in lynx populations. Disturbance of wintering lynx may cause them to expend energy beyond their caloric intake, decreasing natality and increasing mortality. When a disturbance occurs over a large area, Anderson (1995) suggests animal populations could be extirpated in a single winter. Thereafter, food limitation and human disturbance may delay successful recolonization of the area.

MANAGEMENT GUIDELINES

Lynx are very specialized carnivores, requiring snowshoe hares as part of their diet and mature conifer-fir forests for denning. Because of these requirements, lynx are potentially affected by snow-based recreational activities that occur in cold forest habitats. Winter recreation at Potential Opportunity Areas in the GYA may affect lynx as described below.

(1) Destination areas. Human activity at destination areas has the potential to affect lynx, as this species both uses and avoids habitats near human facilities (Halfpenny et al. 1982). Displacement of lynx from winter habitat is an important management concern. Use of ski areas, other resorts, and communities is increasing in the GYA. New developments, or significant increases in existing developments, destroy at least some

lynx habitat and may cause lynx to increase avoidance of habitats that are immediately peripheral to these sites. Downhill ski areas should be designed to reduce impacts on lynx by reducing habitat fragmentation and providing security zones between activity locations (Thompson 1987). Lynx may also habituate to human foods, potentially increasing management problems and lynx mortality. Proper garbage and food storage would reduce unnatural attractants and management actions.

(2) Primary transportation routes and (3) scenic driving routes. Roads, whether they are maintained or unmaintained, provide recreational access. Increased demand for winter recreation may be a catalyst for creating new roads. Roads may increase lynx mortality due to trapping pressure and collisions with vehicles. The road density and traffic volume may indirectly influence levels of lynx mortality. Disturbance associated with automobiles, snowmobiles, and recreationists may pose a risk to denning lynx. More roads may ultimately reduce habitat effectiveness for lynx and increase habitat fragmentation.

(4) Groomed motorized routes. Snowmobile traffic may reduce the effectiveness of lynx habitats that are peripheral to groomed snowmobile routes. Lynx and hares that use habitats in the vicinity of roads may be adversely stressed by disturbance. Night use of roads may be more detrimental than day use because lynx are nocturnal and crepuscular. However, lynx may show some habituation to snowmobile activity where it is temporally and spatially consistent. Restrictions on quantity and timing of snowmobile travel could reduce adverse effects on lynx.

(6) Backcountry motorized areas. Snowmobiles are frequently used in the backcountry at high elevations, often within or near lynx habitat. Because this activity is highly obtrusive and usually dispersed on the landscape, it has a strong potential to displace lynx from their winter haunts, increase stress levels, and reduce the fitness and viability of lynx populations (Cole and Landres 1995).

(7) Groomed nonmotorized routes. Skiing on groomed routes may affect lynx when the activity occurs at high levels. Therefore, skiers should be directed away from high-quality lynx habitat, particularly where lynx are already known to exist.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes could affect lynx where people use trails frequently. Typically, lynx will not be frequently disturbed by these activities because use of ungroomed trails in the GYA, particularly in deep-forest habitats, is still relatively uncommon. However, forest managers may need to restrict access to prime lynx habitat.

(9) Backcountry nonmotorized areas. Dispersed activities such as backcountry skiing, snowshoeing, and camping have the potential to disturb lynx, but these activities may not be adverse because they occur at low levels in the GYA.

NEEDS FOR MANAGEMENT-RELATED MONITORING AND RESEARCH

Managers should develop a GIS-based inventory of snowshoe hare and lynx habitat. Aerial mapping efforts should be supplemented with ground-based work that includes density estimates of snowshoe hare derived from track surveys and pellet counts. The effects of winter recreation and associated off-season activities should be assessed in the context of cumulative effects at scales applicable to lynx populations and landscapes.

Existing knowledge on the distribution, abundance, demography, and habitat requirements is grossly inadequate to conserve lynx populations. A detection and monitoring system for lynx should be developed using ground-based track surveys (*e.g.*, Halfpenny et al. 1995) or cheek-rub carpet patches (J. Weaver, personal communication; Turbak 1998). Surveys should be repeated systematically over time to detect short-term and long-term changes in the distribution and abundance of lynx.

The rarity of lynx in the GYA dictates a conservative approach to managing lynx and their habitat. Maintaining corridors for possible lynx (and other wildlife) migration from northern Montana or Canada would facilitate conservation of this species.

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EFFECTS OF WINTER RECREATION ON MID-SIZED CARNIVORES (WOLVERINE, FISHER, MARTEN, LYNX, BOBCAT, RED FOX, AND WEASEL)

POPULATION STATUS AND TREND

Wolverines (*Gulo gulo*) are con sidered scarce or rare in the Greater Yellowstone Area (GYA). The GYA probably has a small population, but the actual status and range remain uncertain (Clark et al. 1989). Although the U.S. Fish and Wildlife Service has concerns about their population status as well as threats to their long-term viability, the wolverine has not been listed under the Endangered Species Act. The wolverine has been classified as a protected species in Idaho since 1965. It is a species of special concern in both Idaho (native species that are either low in numbers, limited in distribution, or have suffered significant habitat loss) and Montana (species highlighted for data acquisition and subsequent management efforts) and a Priority 3 species in Wyoming (knowledge of this species is so limited that it cannot be adequately evaluated). The wolverine is listed as a sensitive species by Region 4 (Intermountain Region) of the U.S. Forest Service and as sensitive in Idaho by Region 1 (Northern Region) (species for which population viability is a concern) (Clark et al. 1989).

Fishers (*Martes pennanti*) may exist in very low numbers within the portion of the GYA that includes the northern half of Wyoming, but they have been extirpated from the Montana portions of the GYA, and they were never known to occur in the Idaho portion of the GYA (Clark et al. 1989). The fisher is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming. Region 4 of the U.S. Forest Service lists it as a sensitive species (Clark et al. 1989).

Martens (*Martes americana*) are classified as “indicator species” on the Beaverhead, Bridger–Teton, Shoshone, and Gallatin national forests in the GYA. With appropriate management, the marten can be assured a healthy role in the GYA (Clark et al. 1989).

Specific information on the status and distribution of lynx (*Felis lynx*) in the GYA is not available. It is possible that the few reported sightings are of transient animals, but is more probable that a small population persists in the GYA (Clark et al. 1989). The lynx has been proposed for listing under the Endangered Species Act. The lynx is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming (Clark et al. 1989). Region 4 of the U.S. Forest Service lists it as a sensitive species.

The bobcat (*Felis rufus*) and red fox (*Vulpes vulpes*) are managed as furbearers in all three states and may be hunted or trapped during the furbearer season. Populations are considered stable.

The weasel (*Mustela frenata*) is an unprotected species, and little is known about its status.

LIFE HISTORY

WOLVERINE

Wolverines remain active throughout the year, even during the most severe winter weather. They inhabit the coniferous forest zone, generally at higher elevations during the summer and mid- to lower elevations during winter. Lower elevation riparian areas may be important winter habitat. Wolverines generally avoid large parks, meadows, and clearcuts. Wolverines prefer to hunt around small meadows, timbered thickets, cliffs, riparian areas, and ecotonal areas (Clark et al. 1989, USFS 1991).

Females den in late February to early March. The female may move the kits several times prior to weaning, which occurs when kits are 9–10 weeks old. The offspring normally remain near their natal area at reproductive maturation, establishing their home range near that of their mother (Copeland 1996).

Idaho wolverines denned in high-elevation, subalpine cirque basins, locating the den beneath the snow in the tunnels and chambers associated with big boulder talus. Boulder caves beneath deep snow likely provide a stable thermal environment for the protection and rearing of kits. High-elevation subalpine habitat provides seclusion and reduces vulnerability to kit predation prior to weaning. Northeasterly aspects and glacial cirques provide persistent snow coverage and den stability until the mid-May weaning period (Copeland 1996).

FISHER

Fishers prefer extensive, continuous forest canopies such as those found in dense, lowland forests or mature to old-growth spruce-fir forests with high canopy closure. They remain active throughout the year. They appear to be restricted to areas with relatively low snow accumulations, and they travel along snowshoe hare trails or their own previously made trails when snow is deep and fluffy. They avoid open areas such as meadows, grasslands, and clearcuts, and they may be limited by snow depth. Brush piles and large diameter trees, snags, and hollow logs provide critical denning sites in winter. Females usually give birth in tree dens located in high cavities of large trees. The breeding period is March through April (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

MARTEN

Martens remain active throughout the year. They use a variety of forest types, but they are most active in older stands of spruce-fir. In the central Rockies, they are most often associated with old-growth forests in winter. They engage in more aboreal and subnivean activity than other carnivores. They forage on mice and voles, and, as the snow deepens, they switch to pine squirrels and hares. They use meadows, forest edges, and rock alpine areas. The young are born mid-March to late April. The young are reared in dens, and the mother moves the young among dens. The dens are important to recruitment and may represent a special habitat need (Clark et al. 1989, Ruggiero et al. 1994).

LYNX

Lynx are generally found in the northern boreal forest in association with snowshoe hare habitat. Early successional forests with high densities of shrubs and seedlings are optimal habitat for hares and, consequently, important for lynx as snowshoe hares are the major food of the lynx. Hares normally make up 80 percent of the lynx diet, even more when snowshoe hare density is high. Lynx prefer dense lodgepole pine forests for hunting snowshoe hares and higher elevation spruce-fir forests for denning. Mature forest stands are used for denning and cover for kittens as well as for travel corridors. Breeding occurs from mid-March to early April. During this time females seek out males by moving into male territories (Clark et al. 1989, USFS 1991).

BOBCAT, RED FOX, AND WEASEL

This group of carnivores remains active throughout the year. Bobcats use a wide variety of habitats. They need cover to stalk prey and avoid large open areas. Red foxes are also found in a variety of habitats, from heavily forested areas to open meadows and brushy lowlands. Red foxes mate in late winter and den in crevices, caves, or burrows. Long-tailed weasels are extremely solitary (except during the mating period) and are voracious hunters. Weasels often tunnel beneath the snow following prey when hunting during winter (Fitzgerald 1977).

HUMAN ACTIVITIES

Winter recreational activities such as snowmobiling, cross-country skiing, backcountry skiing, and snowshoeing have the potential to affect wolverine, fisher, marten, lynx, bobcat, red fox, and weasel. These mid-sized carnivores have certain biological traits that suggest vulnerability to human uses (in this case, recreational activities) specifically during the stressful winter period. These include low population densities, low reproductive rates, large home range sizes, secretive behavior, and avoidance of humans. The home range sizes of some of the mid-sized carnivores require that they regularly cross snowmobile and cross-country ski trails.

Carnivore foraging behavior in forested areas may be disrupted along groomed trails and other travel corridors. Displacement or avoidance may occur due to noise of snowmachines or to human presence. Snowmobile trails may facilitate travel for some carnivores, but compaction of snow due to grooming or from snowmobile use off existing roads or trails may adversely affect the subnivean habitat of prey species and, therefore, impact foraging opportunities for carnivores.

Existing marked and groomed snowmobile trails and the expansion of these trail systems into new areas facilitates trapping of furbearers and may increase the accidental take of non-target carnivores.

POTENTIAL EFFECTS

Forest fragmentation as a result of timber harvest is a significant source of habitat loss specifically for the fisher, marten, and lynx (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994). Habitat loss could also result from clearing routes for groomed snowmobile and cross-country ski trails. However, routes in the GYA are generally along existing roads and trails, which were developed and are used for summer travel. Dispersed winter activities typically occur within non-forested areas that require no clearing.

Trapping is the most direct way that humans affect carnivore populations, and it can be a significant source of mortality. Overtrapping and accidental trapping of non-target species are considered threats to this group of animals. Highway accidents are another direct human effect on carnivores (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994).

Mortality resulting from an accidental collision with a snowmobile is possible, but the probability is low. Intentional killing of carnivores by a snowmobiler is possible, but most likely it would only occur in rare, isolated incidents.

Winter stress combined with human disturbance/harassment may cause increased mortality to wildlife. Most studies on this topic have been conducted on ungulates, however. Copeland (1996) found that human activities near wolverine dens during the denning and kit-rearing period may cause den abandonment and displace wolverines into suboptimal denning sites. This could result in lower reproductive success and/or kit survival.

Natal dens are also important to recruitment for other carnivores, including the fisher, marten, and lynx. Minimal human disturbance is an important feature when females choose a den site. Fisher and lynx are likely to move to another den if disturbed.

Snowmobile use has been shown to affect snowshoe hare (an important prey species for some carnivores, particularly the lynx) and red fox mobility (Schmid 1983).

Compaction of snowfields by snowmobiles alters the mild snow microenvironment, potentially affecting organisms that live within or beneath the snow by increasing temperature stress or restricting movement by compacting the air spaces between the snow and the ground (Schmid 1983, Boyle and Sampson 1985). Winter mortality of small mammals is markedly increased under areas compacted by snowmobiles. The reduction in population numbers of these small mammals could well reduce the population of species preying upon them (Bury 1978). Fitzgerald (1977) found that the long-tailed weasel often tunnels beneath the snow when hunting during the winter. Raine (1983) found that martens made less use of subnivean space when the snow surface was crusted, probably because of difficult access.

A significant effect on carnivores from winter recreational activities is displacement from or avoidance of high recreational use areas (*i.e.*, groomed trails, marked trails, destination areas, and play areas). Human use will increase where high recreational use areas exist or are provided. As the associated recreational use level increases, the impact on carnivores also increases (Ruediger 1996).

WOLVERINE

A study in Idaho found females sensitive to human activity near the maternal den. The subalpine cirque habitats selected by Idaho wolverines for denning are often preferred winter recreational sites for backcountry skiing and snowmobiling. If females are disturbed during the denning and kit-rearing periods, they may move kits to suboptimal den sites, which may decrease reproductive success and kit survival. In two cases, human disturbance near maternal dens resulted in den abandonment by females and kits (Copeland 1996).

Humans access on snowmobiles or all-terrain vehicles in winter and early spring could cause behavioral disturbances. This disturbance may impair kit survival if females use less secure den sites (Ruggiero et al. 1994).

Other studies found that winter recreational activities affect denning. Nursery dens were abandoned by female and kits upon discovery of human tracks. Human activity around dens in Finland and Norway resulted in den abandonment (Idaho Department of Fish and Game et al. 1995).

FISHER

Fishers appear to be tolerant of moderate degrees of human activity including low-density housing, farm roads, and small-scale logging (Heinemeyer and Jones 1994). In New Hampshire, the presence of human activity and domestic animals appeared to have little effect on fisher movement (Heinemeyer and Jones 1994). Fishers in Maine tolerate a marked degree of human activity (Heinemeyer and Jones 1994). In Idaho, fishers were commonly observed in close proximity to occupied residences. They rarely flushed from their roost sites when researchers approached within a few feet. Females with kits may be more sensitive to disturbance and may move their kits periodically to new dens (Heinemeyer and Jones 1994).

Other studies show that fishers generally are more common where densities of humans are low and human disturbance is reduced. They are secretive, usually avoid humans, and seldom linger when they become aware of the presence of humans. The females use one to three dens and are more likely to move if disturbed. Indirectly, human activities may lead to negative impacts on fishers through increased human access to fisher populations (USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

LYNX

Human access into remote areas may have direct and indirect negative effects on lynx populations. During winter and summer, lynx travel along roadways, which may make them more vulnerable to human-caused mortality (Ruggiero et al. 1994). Lynx are believed to be susceptible to human-caused disturbances during the denning period, and it is believed that females will move kittens (thereby increasing the chance for mortality) in response to disturbance. Minimal human disturbance is an important feature of the den site (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Lynx are specialized deep-snow predators, an adaptation that permits them to live year-round at high elevations, thereby minimizing competition during the physically stressful winter months. Snowmobile or cross-country ski trails allow lynx competitors to infiltrate high-elevation habitats during winter, thereby increasing competition for a limited food supply (Idaho Department of Fish and Game et al. 1995).

The mid-sized carnivores in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

- (2) Primary transportation routes
- (3) Scenic driving routes
- (4) Groomed motorized routes
- (5) Motorized routes
- (6) Backcountry motorized areas
- (7) Groomed nonmotorized routes
- (8) Nonmotorized routes
- (9) Backcountry nonmotorized areas
- (10) Downhill sliding (nonmotorized)
- (12) Low-snow recreation areas

MANAGEMENT GUIDELINES

A literature search produced little information on how winter recreational activities impact carnivores; research on carnivores is extremely expensive and is mostly non-existent on mid-sized carnivores. Biologists, land managers, and recreation specialists will therefore need to practice “adaptive management” and “professional judgement” when developing winter use or recreational management plans until more information is available.

Existing winter trail systems/play areas and the development of new trails or designation of new play areas, particularly new areas, should be considered a negative impact on mid-sized carnivores. To avoid impacts, public land managers should exclude recreational activities from important areas that are used by carnivores during the winter.

Copeland (1996) recommends that management exclude human recreational activities within a five-mile buffer of predicted wolverine denning habitat from January 1 to May 31. Recreational activities outside the restricted time period should be managed for minimal intensity (*e.g.*, institute skier/snowmobile quotas and/or weekend closures).

Wolverines were specific in the sites they selected for natal and maternal dens in central Idaho. For example:

- Dens were situated above 8,000 feet in elevation. Although this elevational demarcation may vary throughout the wolverine’s regional distribution, it is likely applicable within the Targhee National Forest.
- Dens tended to be within a north-northeast aspect range (between compass readings greater than 320 degrees and less than 130 degrees).
- Dens selected had zero vegetative overstory (bare-exposed rock cover type).

- Den sites tended to be in the concave physiographic landscape feature of a glacial cirque.

Conserving wolverines may require large refugia connected by adequate travel corridors. Refugia provide core habitat for wolverine populations. Security areas must be available to provide undisturbed seclusion for reproducing females. Federal land-use regulations need to provide flexibility in administering backcountry winter recreational access and management (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Providing protected areas within optimal habitat in the western mountains may be important to the persistence of lynx (Ruggiero et al. 1994). A strict, no-access management program is not recommended, but, rather, a proactive effort that involves community education and participation to protect lynx (Idaho Department of Fish and Game et al. 1995).

In many cases managers may have to use professional judgement combined with common sense to conserve the mid-sized carnivores. When conflicts occur between winter recreational activities and protection of carnivores, managers should err on the side of the carnivores. The winter period is a critical time for survival because of the extremely harsh weather conditions in the Greater Yellowstone Area.

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EFFECTS OF WINTER RECREATION ON MOOSE

The distribution of moose (*Alces alces*) corresponds to environments where snow is a dominant feature in the winter. Moose are anatomically and behaviorally suited for areas where winter conditions can be harsh. These are often the same areas where humans pursue winter recreational activities. Because of this, there is a strong potential for some types of winter recreation to affect moose.

POPULATION STATUS AND TREND

Moose may have been rare in western North America during historic as well as pre-Columbian times (Peterson 1955, Kelsall and Telfer 1974, Kay 1997). However, since about 1900 moose appear to have extended their range and/or become more numerous (Kelsall and Telfer 1974, Kay 1997).

Estimating moose population size has proven to be a consistent problem in many areas (Timmermann 1974, 1993; Gasaway et al. 1986), and a lack of accurate estimates has hampered good management (Gasaway et al. 1986). Some attempts to determine moose population status and trend in the Greater Yellowstone Area (GYA) have been equally problematic (Tyers unpublished data, Gasaway 1997), and a good count for this region has not been achieved. Although demographic data are not available at a large landscape level, it is known that moose are uncommon compared to other ungulates in the GYA. In addition, populations are often at low density. In these circumstances, a conservative approach to moose population management is advised (Tyers unpublished data, Gasaway 1997, Karns 1997).

Some information on moose populations in the GYA is available. Houston (1982) reported that moose remains have not been found in archeological sites in northwest Wyoming or south central Montana. He concluded that moose had not yet occupied northwest Wyoming in 1830 (Houston 1968), but had colonized the Yellowstone area by the 1870s; they appeared on Yellowstone's northern range around 1913 (Houston 1982). Schullery and Whittlesey (1992) reviewed the documentary record for wolves and related wildlife species in the Yellowstone National Park area prior to 1882. Based on historic accounts, they concluded that moose were common in the southern part of the park in 1882, and rare sightings were made near or on the northern range about the same time.

Recent studies indicate a population decline following the 1988 Yellowstone fires in areas where fire effects were severe and in areas where moose rely on older lodgepole pine forests for winter range (Tyers unpublished data, Tyers and Irby 1995). In response to these data, Montana Fish, Wildlife and Parks has significantly reduced hunting quotas in districts north of Yellowstone National Park (T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In portions of the GYA where moose have different winter-use patterns or where fire effects are not an issue, the trend may be different.

Several hypotheses have been proposed to explain the biogeography of moose in western North America. Kelsall and Telfer (1974) presented five hypotheses to explain the relatively recent expansion of moose. These include: (1) moose have had a limited amount of time to colonize North America since the last glaciation; (2) climatic variation—the Little Ice Age and associated severe winter weather limited moose populations around

1700–1800; (3) disease once limited moose numbers; (4) European settlement modified the original climax forests, which were poor moose habitat, and created seral vegetation types that moose prefer; and (5) predators once limited moose, but the near extermination of native carnivores allowed moose to extend their range and expand their populations.

Kay (1997) proposed a sixth hypothesis: moose were extremely vulnerable to predation by Native Americans who had no effective conservation practices. The result was a control of moose biogeography by native hunting.

Loope and Gruell (1973) proposed a seventh hypothesis specific to the GYA: a very low moose population during the 19th century was the result of fires, which maintained early successional vegetation. They speculated that moose populations have increased in this century in northwest Wyoming as forests have matured under a management policy of fire suppression. A primary factor in this, they believe, is an increase in subalpine fir, a shade-tolerant species found in older forests. They further hypothesized that subalpine fir is the staple food item in the diets of moose in the area. Tyers (unpublished data) tested this hypothesis and demonstrated that moose along the northern border of Yellowstone National Park feed primarily on subalpine fir saplings in older lodgepole forests.

Although the Shiras moose is a relatively recent arrival to the GYA, available habitat is now occupied. However, future population trends are uncertain. Habitat conditions, human influences, and exposure to predation vary considerably across the GYA. In addition, the small home range size of moose and the strong fidelity moose show to a geographic area tend to create many fairly discrete populations. For these reasons, it is likely that local populations will display very different trends.

As evidenced by the hypotheses for recent moose range expansion explained above, future trends in the GYA will be largely determined by predation and habitat quality. Humans, bears, and wolves prey upon moose in the GYA. The recent reintroduction of wolves is an important variable with unknown consequences. Some have speculated that wolves will play a major role in regulating moose populations, and a decrease in moose numbers will be noticed (Messier et al. 1995). The 1988 Yellowstone fires were a landscape-level disturbance that affected the successional stage of vegetation. This will undoubtedly be a determining factor for moose populations in a large spatial and temporal context. In many parts of the GYA, a return to an early successional stage represents a decrease in moose winter habitat that will reduce carrying capacity (Tyers unpublished data). Riparian areas with deciduous vegetation are important foraging areas for moose. They are limited in size and distribution and are particularly vulnerable to human impacts. Management of these areas will also play a role in determining moose population trends.

LIFE HISTORY

Moose are seasonal breeders with the mating season in the fall and calving in the spring. Most cows ovulate for the first time between 16 to 28 months of age, although those in populations on poor range may not breed until 40 months. Most cow moose produce either single or twin calves. Twinning varies widely across North America and may be correlated to habitat quality and carrying capacity. Triplets have been reported but are rare. Most cows produce a calf or calves each year. Neonatal predation is common and can be high (Schwartz 1997). Average life span is highly variable; generally, it may be 7 or 8 years with a maximum age at possibly 20 (Ballard and Van Ballenberg 1997).

HABITAT

As a generalization, the moose is an animal of the boreal forests—the coniferous forests that occur in a broad band across northern North America and Eurasia. Boreal forests also extend southward at higher elevations in the mountains. The climate within this biome is characterized by cold winters and short, mild summers (Brewer 1994). Food and cover are the primary factors limiting geographic distribution in the north (Kelsall and Telfer 1974), and climate is the factor in the south (Reneker and Hudson 1986). The most critical factor, especially to the southern distribution of moose, is temperature (heat) (Karns 1997).

Moose are browsers—herbivores that eat primarily shrubs and trees (Peterson 1955, Renecker and Schwartz 1997). Specifically, they eat twigs and foliage high in cell-soluble sugars that ferment readily in the rumen. These are foods that are considered to be, comparatively, of poor quality. In addition, they are characterized as concentrate selectors. Because of their body size, they require large amounts of abundant food to survive. To satisfy this need, they seek out concentrations or patches of biomass in the environment where they can spend relatively long periods of time foraging. For example, moose seek out or select willow (*Salix* spp.) that often offers large amounts of forage bunched together on the landscape. Because of their dietary constraints, the quantity of biomass for foraging determines moose density.

The large body size of moose is an advantage in boreal regions for coping with predators and periods of extreme cold and deep snow (Renecker and Hudson 1986, 1989). However, it also imposes limitations on activities. Moose have a difficult time dissipating heat, and heat stress can lead to a reduction in overall activity during warm periods. Ambient air temperatures above 23° Fahrenheit in winter and above 57° Fahrenheit in summer can be stressful and can cause moose to seek cooler areas. In a broader sense, problems with thermal regulation restrict range expansion into more temperate climates.

Telfer (1984) placed moose habitat in six broad categories: boreal forests, mixed forest, large delta floodplains, tundra, subalpine shrub, and stream valleys. These may be further described as either permanent or transitory in nature (Geist 1971, Peek 1997). Permanent habitats are those that persist and do not succeed over time to a different pattern of vegetation. For example, alluvial habitats are dynamic in that flooding and streambed alteration produce a constantly changing system, but they are permanent in the sense that the same type of vegetation is present after a disturbance. Boreal forests are more transitory. Fire can radically alter the vegetative composition; a mature forest can be changed to a shrub community. The shrub community will eventually be dominated by a forest that is vulnerable to a fire event just as the first one was. The pattern is cyclic, and each successional stage is transitory to the next.

Throughout much of their range, moose are found in transitory habitats. Specifically, they are closely linked to early seral stages where shrub biomass is plentiful (Dryness 1973, Wittinger et al. 1977, Irwin and Peek 1979). In many areas, moose benefit from the removal of the forest canopy (Taber 1966, Krefting 1974, Kelsall and Telfer 1974, Leresche et al. 1974, Irwin 1975, Peek et al. 1976). Disturbances such as fire, logging (or other forms of mechanical manipulation), disease, or wind events can create favorable moose habitat by removing trees that compete for resources with shrubs.

However, it is also known that moose winter habitat-use patterns can be highly variable between regions and years (Peek 1974a), which reflects adaptive responses to different environmental conditions. Peek (1974a) cautioned against making unequivocal generalizations about moose winter habitat selection and suggested that the amount of variability can make these descriptions misleading. Included are statements about the role of transitory habitats, forest canopies, and seral stages in moose habitat. He stated that this variability has special consequences to management because it is important to determine the forage species locally preferred by moose and then favor those species through management actions.

Snow conditions have an important influence on moose habitat-use patterns (Peek 1997). Conditions include temperature, density, hardness, and depth (Peek 1997), and factors that affect the ability of moose to access browse (Peek 1971, Schladweiler 1973). The presence or absence of a forest canopy can have a significant effect on snow conditions. For example, moose often prefer open brush fields for foraging where browse is abundant. They have also been known to seek coniferous forests when snow conditions impeded movements in open areas (des Mueles 1964, Kelsall 1969, Telfer 1984, Peek et al. 1976, Rolley and Keith 1980, Thompson and Vukelich 1981). Travel in forests is often less energy demanding because tree branches ameliorate snow density, hardness, and depth through shading and intercepting falling snow.

Several studies have reported specific snow depth thresholds for moose. Snow depths of 25.5 inches have been reported to affect habitat use and movements of moose (Kelsall 1969, Thompson and Vukelich 1981, Pierce and Peek 1984). In Quebec, des Mueles (1964) found that moose shifted to more dense coniferous areas when snow depth reached 30 to 34 inches, and moose did not use areas where the snow exceeded 42 to 48 inches, even when the snow was soft. Kelsall (1969) reported moose were severely restricted by snow depths of 27.5 to 35.5 inches. Kelsall and Prescott (1971) found that when snow depths reached 38 inches in New Brunswick moose where confined to areas with high forest canopies. Tyers (unpublished data) demonstrated that moose on Yellowstone's northern range avoided snow depths greater than 31.5 to 43 inches and were not found when snow exceeded 54.5 inches.

Peek (1974a) reported on the variability in the winter habitat used by moose in North America. He reviewed 41 different reports: 13 from the Intermountain West; 6 from Alaska; and 22 from Canada, Minnesota, and Maine. His review highlighted the variation and commonality in the diet and forest successional stage used by moose. In another document (1974b) he focused on the Shiras moose. He identified five different types of winter habitat for the Shiras moose in the Intermountain West, an area that includes the GYA:

1. Willow bottom/stream/conifer complex occurring along high-gradient streams.
2. Flood plain riparian community containing extensive willow stands.
3. Drainages where willow-bottom communities are very limited and are of little importance to moose, but where conifer and aspen types are important, and the diet is more varied than in areas where willow is plentiful.
4. Arid juniper hills.
5. Willow communities that are important but are neither limited nor extensive. Moose are forced from these areas by snow conditions into adjacent forested slopes where subalpine fir stands support low-density moose populations in winter.

Studies conducted in the GYA portion of the Intermountain West accent the variability of moose habitat use. The results generally fit into one of Peek's (1974b) five categories, but there are important differences in habitat use by moose in this area and the moose of other areas. For example, McDowell and Moy (1942) did a descriptive study of moose habitat use in the Hellroaring/Slough Creek area north of Yellowstone National Park (Peek's Type 5). They noticed an early winter association of moose and the limited willow areas, and then a move to adjacent conifer types, presumably in response to increasing snow depths. Harry (1957) and Houston (1968) documented use by moose of the extensive willow areas on the flood plains of Jackson Hole, Wyoming (Peek's Type 2). Stevens (1970) found Douglas fir and aspen communities to be the key winter range in the Gallatin Mountains (Peek's Type 3). Tyers (unpublished data, Tyers and Irby 1995) investigated moose habitat use on Yellowstone's northern range and documented moose using older lodgepole pine forests during the most difficult winter months where they browsed almost exclusively on subalpine fir saplings and seedlings (Peek's Type 5).

HUMAN ACTIVITIES

There are few examples in the literature that describe the effect of various types of human activity on wintering moose. Although several studies address changes in movements and habitat use, none appear to demonstrate resulting demographic changes.

Moose are thought to be comparatively tolerant of humans and to have the ability to develop a high level of habituation (Shank 1979). This is illustrated in several ways, including flight distance. Moose unaccustomed to humans usually run about 150 yards, but habituated individuals may allow approaches to within 20 to 25 yards (Shank 1979). As a further example, Westworth et al. (1989) found that moose in British Columbia were able to habituate to disturbances associated with surface mining, including vehicular traffic, plant machinery, and blasting of ore reserves. Pellet group densities, used as an index of moose abundance, were highest on a transect 100 yards from the open pit. This transect had a particularly high density of browse leading the authors to concluded that moose distribution was influenced more by browse availability among different habitat types than by disturbance associated with mining. Pellet groups also demonstrated moose activity as close as 15 yards from the pit at sites where browse was present.

The response of moose to the mine in British Columbia (Westworth et al. 1989) and similar situations may be explained by a theory proposed by Geist (1971). He stated that if visual and acoustical stimuli are predictable in space and time, the process of habituation by wildlife is enhanced. Mine activity and some forms of winter recreation can be predictable. In contrast, panic responses may occur as a result of any kind of abrupt unexpected intrusion (Busnel 1978).

Westworth et al. (1989) proposed that the mine was actually an asset to moose. Moose in the area are exposed to predation by wolves. The mining activity displaced wolves, offering security to moose not available away from the mine site.

Rudd and Irwin (1985) investigated impacts to wintering moose resulting from oil and gas extraction and recreational activities in western Wyoming. The number of shrub species available in proximity to a plowed road was the best predictor of moose presence or absence. Relative to people on snowshoes, skis, or snowmobiles, trucks associated with resource extraction caused the greatest disturbance to moose. People on snowshoes or skis caused more disturbances than snowmobiles. The average distance 18 moose ran to escape trucks was 16.9 yards, and the average distance at which moose where displaced was 169 yards; 21 percent were displaced, and 48 percent showed some type of disturbance behavior. The average distance 19 moose moved away from people on snowshoes or skis was 16.6 yards, and the average distance at which moose were displaced was 80.7 yards; 17 of the 19 moose moved to a different location, and all showed signs of disturbance. The average distance 242 moose ran to escape a snowmobile was 10.5 yards, and the average distance at which moose were displaced by snowmobiles was 59.25 yards; 50 percent of the encounters between moose and snowmobiles resulted in displacement while 94 percent showed some form of disturbance. Rudd and Irwin (1985) recommended that winter recreational use and mine activity be restricted near preferred moose winter range.

Ferguson and Keith (1983) addressed the influence of nordic skiing on moose and elk in Elk Island National Park, Alberta. They found that cross-country skiing influenced the general over-winter distribution of moose. Moose tended to move away from areas near heavily used trails more than lightly used trails during the ski season (January through March). Daily movements away from trails occurred after the onset of skiing. However, once displacement occurred, additional skiers did not generate a greater displacement.

The flight behavior of moose is unusual and often misinterpreted. Their reputation of being tolerant to humans may in part be because their stress response is more subtle than that of other ungulates. Shank (1979) reported a common response of moose to a disturbance was that they rarely reacted immediately and overtly to disturbing stimuli unless that stimulus was very intense. Often, they continued feeding and might even increase the intensity of feeding. While this is occurring, they moved without obvious sign of stress toward cover. Once cover was reached, they usually looked directly at the source of the disturbance, often for the first time, and then ran. Until the moose bolts, stress may not be obvious because it is expressed in less noticeable physiological responses, such as increased breathing and elimination rates.

Reports dealing specifically with collisions between wintering moose and vehicles and trains are more common. Examples can be found from most areas with important moose populations. Because winter recreation frequently involves plowing roads and accessing recreation areas with motorized conveyance, the topic is relevant.

Lavsund and Sandegren (1991) reviewed moose/vehicle relations in Sweden and described the situation as a serious problem both in terms of human safety and mortality of moose. Risk was highest at dawn and dusk and higher at night than during the daytime. In southern Sweden where winter snow accumulation is less important, collisions peak in early summer during calving and in autumn during the rut. In northern Sweden, collisions peak during December and January when snows initiate moose migrations to lowland ranges where major roads are common. Various methods were tried to reduce the number of moose/vehicle collisions. Repellants in the form of flashing lights, sounds, and scents were not effective. The results of roadside clearing to improve visibility for drivers demonstrated a reduction that was no better than what might have been arrived at by chance. Efforts to educate drivers on how to scan the roadside and anticipate risks did not seem to change driver behavior—good drivers were cautious, and bad drivers remained incautious. Neither road authorities nor drivers were interested in reducing the speed limit. Fencing the roads was effective at reducing collisions by 80 percent.

In Alaska, measures were taken to mitigate moose/vehicle collisions along a stretch of highway that was improved (Child et al. 1991). A moose-proof fence, moose underpass, and highway lighting all were effective at significantly reducing collisions. Collisions were reduced 95 percent in the fenced portion of the highway when compared to the previous decade before the highway was improved and mitigation measures were put in place. The reduction in loss of moose allowed an increase in hunter harvest. Child et al. (1991) estimated that approximately 10 percent of the annual allowable harvest in the province of British Columbia die as a result of collisions on highways and railways. The impact of this on the demographics of the moose population is unknown.

Collisions between moose and motorists on the Kenai Peninsula, Alaska, were also reported to be a severe problem (Del Frate and Sparker 1991). The number of road-killed moose nearly doubled following the new policy of the Department of Transportation to improve snow-clearing efforts. Better road conditions allowed motorists to travel faster. Collisions also increased during a severe winter when moose sought relief from harsh snow conditions by attempting to winter close to plowed roads. In response, a public awareness program was started using roadside signs, bumper stickers, and programs in schools. The number of moose mortalities declined 18 percent the following year, but the authors were not confident the education program was responsible. The results were confounded by mild winter conditions that allowed moose to winter farther from the roads. As mitigation, they called for avoiding building roads in moose winter range, brushing roadsides to increase visibility, and fencing.

Rudd and Irwin (1985) found that site features had some effect on how moose tried to escape humans. When exiting roads freely, moose selected areas with less steep slopes than random samples, especially slopes of less than 5 percent. In 83 percent of the cases, moose exited at points where snow depth along the road was less than the average depth, although this difference was not statistically significant. During forced exits, moose chose slopes in proportion to what was available. The average snow depth of the berm was significantly greater along the road than where moose exited under duress. The average canopy closure was significantly greater at these exit spots than in random samples.

Bubenik (1997) reported that mature, healthy moose stand their ground when confronted by wolves, and inexperienced moose generally run and are killed. Child et al. (1991) and Bubenik (1997) saw a connection between this and the high incidence of collisions with trains. Moose use the same survival strategy during confrontations with trains as they do with wolves. With trains this tactic is fatal. The problem is exacerbated by the effect of headlights, which hypnotize moose and interfere with avoidance movements.

Anderson et al. (1991) determined that snow conditions greatly influenced annual variation in moose killed by trains in Norway. Mean annual snow depth was able to explain 84 percent of the annual variation in train kills. They believed three factors were responsible for this close correlation. First, early snows seemed to increase the speed, timing, and magnitude of moose movements to winter range. This places them on train tracks earlier in the season. Secondly, although moose are morphologically adapted for survival in snow, snow depths of greater that 39 inches seemed to motivate moose to seek the plowed railroad beds for movements between feeding sites.

Third, as snow depths increased moose were less successful at escaping the tracks in the face of oncoming trains. Because of snow conditions they returned to solid ground on the tracks and tried to outdistance the approaching train instead of climbing over the snow berm. In addition, more collisions occurred after dark when moose were more active; they became hypnotized by train lights and train personnel had greater difficulty observing moose. They also found temperatures below 20° C tended to increase the risk of collision, while temperatures above 0° C had the opposite effect. The authors speculated this occurred because moose are foraging more actively at lower temperatures.

Becker and Grauvogel (1991) investigated moose/train collisions in Alaska. They observed that most moose that were struck were using the tracks as a travel corridor in a winter environment. Most had time to exit the tracks but, instead, usually tried to outrun the train. Snow depths were around 35.5 inches, and moose that did leave the tracks floundered and returned to the tracks, which probably increased their sense of vulnerability to a perceived predator, the train. They experimented with decreasing the average speed of the trains (from 48 to 25 miles per hour) to see if moose mortalities could be reduced. The reasoning was that at a reduced speed there would be more reaction time for train personnel and more time for moose to escape. The reduction did not reduce the number of moose mortalities, and the train company determined that, based on economics, they could not afford to reduce the train's speed below 25 miles per hour. The authors believed that a threshold did exist below which a positive response would occur, but it appears to be below 25 miles per hour, which is not economically practical for the train company.

Modafferi (1991) also investigated the relationships between moose/train collisions, snowpack depth, and moose distribution. The setting was the lower Sustina Valley in Alaska. More than 73 percent of mortalities occurred from January through March. Mortality was greatest along stretches of railway that passed through moose winter range. As snow depth increased, mortalities increased.

POTENTIAL EFFECTS

The literature indicates moose can be impacted by human activities in the winter. However, moose habitat requirements are specific, and their use of selected areas is traditional. The presence or absence of moose winter activity is easy to verify through tracks, pellet groups, beds, sightings, and evidence of browsing. Investigations in summer or winter will demonstrate whether or not moose are using the area as winter range. As discussed, the specific attributes of moose winter range are variable. However, in all cases a winter range will include a concentration of accessible browse material such as deciduous trees and shrubs, especially willow and aspen. In some cases, browse may be subalpine fir saplings. Cover, in the form of dense coniferous forests, may also be present. Some of the best moose winter range is found where browse concentrations are in juxtaposition with cover. If snow conditions preclude access to the browse, moose will not be present.

Impacts of recreational use may take several forms. Moose may be negatively impacted by a loss of winter habitat if construction of facilities removes habitat features resulting in a loss of foraging opportunities or cover. Negative impacts may also occur if moose are subject to displacement that results in a drain on energy reserves. Because they are often in an environment where snow is deep, flight can be energetically costly. The literature indicates flight and stress are most likely when the source of the disturbance is unpredictable, is severe to sensory perception, and is in close proximity. There is also the possibility that if disturbances are not of this nature, moose may habituate to human activities and show high tolerance. Moose may even seek centers of human activity as security from predators.

Moose are also uniquely vulnerable to mortality by collisions with vehicles. This is because of the relationship between moose, browse availability, and snow conditions. Plowed roads or train tracks in moose winter range offer moose relief from snow conditions as well as travel corridors to sources of browse. This, combined with their instinctive response of standing their ground in the face of a perceived threat help explain why this is such a serious problem in many areas. Winters with above average snow depths exacerbate the problem.

Moose in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact moose. Habitat can be lost if facilities are built in moose winter range. Individual animals can be affected if a flight response is initiated through contact with humans or their dogs. If human activities are predictable, moose may become habituated. If predation is intense, moose may even seek the site as a refuge.

(2) Primary transportation routes and (3) scenic driving routes. Human activity along driving routes has the potential to negatively impact moose. Habitat can be lost through road construction. Individual animals can be affected by collisions with vehicles or by energetically expensive flight responses.

(4) Groomed motorized routes and (5) motorized routes. Individual animals may be affected if a flight response is initiated by contact with vehicles. Moose may use the groomed surface as a travel route and invite collisions with oversnow vehicles. If human activities are predictable, moose may become habituated.

(6) Backcountry motorized areas. Because of the way humans recreate in these areas, it is unlikely their activities will be predictable to moose. Routes, time of day, and numbers of people will be highly variable. As a result, there is a high probability of initiating a flight response and a low probability of habituation occurring. In addition, there is a chance snowmobilers will approach or even chase moose because their movements are unrestricted. This could be energetically very expensive for moose.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. Human activity may initiate energetically expensive flight responses. If human activity is predictable, some level of habituation may occur. Because established routes will be used, the chance that habituation will occur is enhanced. Moose may use groomed routes as travel corridors making encounters with people more likely. However, because the activity will not be motorized and grooming vehicles move slowly, collision is not a risk.

(9) Backcountry nonmotorized areas. Because of the way humans use these areas, it is unlikely their activities will be predictable to moose. As a result, there is a high probability of initiating flight response and a low probability of habituation occurring.

In addition, there is a chance that skiers will approach moose because their movements are unrestricted, which could be energetically expensive to moose. However, it is less likely skiers will actually chase moose.

(10) Downhill sliding (nonmotorized). These areas are usually limited in size. Unless they are located in especially productive moose winter range, impacts should be minimal.

(12) Low-snow recreational areas. Moose winter range is usually at higher elevation where snow accumulation is comparatively greater. More xeric habitats do not provide moose forage. A possible exception is riparian areas at low elevation that may be used by moose as winter range. In these instances, moose could be impacted by a loss of habitat or by displacement. However, flight responses would not be as energetically expensive as it would be in locations where snow conditions are deeper.

MANAGEMENT GUIDELINES

- Avoid building winter recreational facilities in moose winter range. This will prevent a loss of habitat and reduce encounters that elicit energetically expensive flight responses. As stated, moose winter range is not difficult to identify. All components of the wintering area should be considered, including foraging areas, cover, and travel corridors.
- Where human use does occur in moose winter range, regulate activities to make them as predictable as possible. This can be accomplished by restricting them spatially and temporally. For example, restrict skiing or snowmobiling to designated paths and to daylight hours.
- Where plowed roads exist in moose winter range, reduce the risk of collisions by plowing escape corridors in roadside snow berms, reducing speed limits, alerting motorists to the risk by signing and other educational efforts, providing roadside lighting, restricting travel to daylight hours, fencing road corridors, providing underpasses for moose to cross the road, and removing roadside barriers that limit visibility.
- Educate the public so that they can take appropriate measures to avoid impacting moose. They should understand the impacts of chasing or approaching moose and the importance of controlling the movement of dogs.
- A monitoring program should be established to follow moose population trends and assess potential conflicts with moose. A variety of methods are available with which to develop either an index with comparatively little investment or to conduct a more intense survey (Tyers unpublished data; Timmermann 1974, 1993; Gasaway 1997).

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EFFECTS OF WINTER RECREATION ON MOUNTAIN GOATS

POPULATION STATUS AND TREND

Mountain goats (*Oreamnos americanus*) were historically distributed in North America in the western coastal ranges from Alaska to northern Washington and in the Rocky Mountains from northern Canada to northern Montana and central Idaho. Through introductions, primarily by state wildlife agencies, their distribution has been successfully expanded into vacant habitats in their historic range, as well as in habitat outside their historic range in the western United States (Johnson 1977, Wigal and Coggins 1982). Mountain goats were introduced into the Greater Yellowstone Area (GYA) by state fish and game agencies in Montana and Idaho for recreational purposes, including hunting (Brandborg 1955, Montana Department of Fish and Game 1976, Hayden 1984, Swenson 1985, Laundre 1990, Varley 1995). Most introductions took place between 1940 and 1960 and were successful in achieving self-sustaining populations. Many of the founder herds were productive and colonized unoccupied areas, including mountain ranges that did not receive transplants, such as the Gallatin Mountains. Currently mountain goats inhabit most mountain ranges with appreciable alpine habitat in the GYA (see Table 2). The population trend for goats in these areas is generally stable or growing (Swenson 1985, Laundre 1990, Lemke 1996), and most herds sustain a conservative annual harvest.

LIFE HISTORY

Mountain goats are social animals generally found in small groups (Brandborg 1955, Chadwick 1977), though single individuals are commonly encountered. During most of the year, adult males generally avoid adult females except where centralized resources, such as mineral licks, bring them together. Males court females during the breeding season in November and early December then leave the female group sometime during the winter (Brandborg 1955, Chadwick 1973, Smith 1977, Wigal and Coggins 1982).

Mountain goat populations are generally considered to be slow growing and have low productivity (Eastman 1977, Stevens 1983, Chadwick 1983). Goats become sexually mature at the age of 2.5 (these goats give birth

Table 2. Mountain ranges in which goats are found in the Greater Yellowstone Area

Mountain Range	Population[1]	State	References[2]
Absaroka Range	360–490	MT, WY	Swenson 1985, Varley 1995
Beartooth Mountains	365–425	MT, WY	Haynes 1992
Bridger Range	85–90	MT	
Centennial Mountains	No estimate	ID, MT	
Crazy Mountains	175–200	MT	Lentfer 1955, Saunders 1955, Foss 1962
Gallatin Mountains	50–60	MT, WY	
Gravelly Range	No estimate	MT	
Madison Range	No estimate	MT	Peck 1972
Palisade Range	128–142	ID, WY	Hayden 1984, 1989
Tobacco Roots	No estimate	MT	

[1] 1993 estimates from surveys conducted by Montana Fish, Wildlife and Parks from Lemke (1996).

[2] General population status, distribution, and ecology information specific to these populations.

at 3) or 3.5 (these goats give birth at 4), depending upon conditions (Houston and Stevens 1988), though productive conditions can, in rare cases, lead to maturity at the age of 1.5 (Stevens 1983). Gestation is about 6 months, and offspring are born in late May or early June. Females most often have one offspring. Though two and even three kids have been documented, it is considered rare and an indication of productive conditions (Lentfer 1955, Foss 1962, Hayden 1984, Houston and Stevens 1988, Festa-Bianchet et al. 1994, Varley 1995). Mountain goat kids often remain with their mothers for 10–11 months, or longer if the mother does not produce a new kid. Because of social aggression, the association between a mother and kid can be critical to kid survival during winter (Chadwick 1977). At age two or three, males leave female groups and join male groups or become solitary, while females typically stay with groups (Brandborg 1955, Wigal and Coggins 1982, Chadwick 1983). Both sexes are capable of dispersing long distances and often will at young ages (Chadwick 1973, Stevens 1983, Hayden 1989, Varley 1995).

The greatest factor in natural mortality of mountain goats appears to be winter severity and, in particular, snow depths (Adams and Bailey 1982, Wigal and Coggins 1982, Swenson 1985). Snow depth and snow morphology are often the underlying factors in the causes of death in mountain goats. Causes of death include the availability of winter forage and its effect on body condition (Brandborg 1955, Edwards 1956, Holroyd 1967); the frequency of intraspecific interactions and the resulting levels of stress (Petocz 1972, Chadwick 1977, Kuck 1977, Smith 1977, Foster and Rahs 1982); the susceptibility to accidents, including avalanches and falls (Holroyd 1967, Chadwick 1983, Smith 1984); the susceptibility to disease and parasites (Wigal and Coggins 1982); and the susceptibility to predation (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982). Of all natural causes, accidents related to avalanches; rock, snow, and ice fall; and precipitous falls appear to account for most natural deaths (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982, Wigal and Coggins 1982, Chadwick 1983, Smith 1984).

HABITAT

Throughout their range, mountain goats inhabit steep, rocky terrain during all seasons of the year. No other feature of preferred habitat is more apparent than the rugged inclines to which goats are adapted. They are often found on slopes between 20 and 60 degrees with little vegetative cover (Smith 1977, Varley 1995). They use cliff ledges for all activities including resting, feeding, and playing (Chadwick 1973, McFetridge 1977). They also use the slide-rock, talus, and turf meadows adjacent to ledges, though they rarely stray far from the safety of cliff habitat (Saunders 1955, McFetridge 1977, Varley 1995).

Goats typically migrate between summer and winter ranges each fall and spring (Brandborg 1955, Holroyd 1967, Kuck 1977, Smith 1977, Wigal and Coggins 1982). These migrations are often short-distance elevational shifts to adjacent areas, versus the lengthy migrations to distantly separated ranges known to occur with mountain sheep and elk (Holroyd 1967, Chadwick 1973, Varley 1995). The use of transitional ranges between summer and winter ranges is atypical (Kuck 1977).

In the Rocky Mountains, summer ranges are often high-elevation settings such as the tops of mountain ridges and peaks above timberline (Brandborg 1955, Holroyd 1967, Wigal and Coggins 1982). In the GYA, these areas are typically between 8,500 and 12,000+ feet in elevation. During the summer months, goats use alpine meadows, slide-rock slopes, talus, and cliff ledges and usually avoid timbered areas (Saunders 1955, McFetridge 1977, Thompson 1981, Varley 1995).

Goats descend to lower elevations in autumn, often after the first deep snowfall, and use terrain topographically similar to their high-elevation habitats. In some populations, goats remain in high-elevation areas during the winter and feed on very steep and/or wind-blown slopes and ridges where snow does not accumulate (Brandborg 1955, Saunders 1955, Hebert and Turnbull 1977, Wigal and Coggins 1982), however, most populations have winter ranges distinctly lower in elevation (Brandborg 1955, Chadwick 1973, Kuck 1977, Wigal and Coggins 1982). Winter habitats can be below timberline, varying in elevation depending upon local topography, though the particular areas in use for non-coastal populations tend to be non-forested areas or open-canopied forests (Gilbert and Raedeke 1992).

The principal factors in mountain goat winter range habitat selection seem to be close proximity to cliff habitats and low snow accumulations (Brandborg 1955, Smith 1977, Smith 1994). Thus, the preferred habitats are often steep and rocky, located on south-facing slopes, and exposed to wind and sun (Brandborg 1955, Chadwick 1973, Gilbert and Raedeke 1992, Smith 1994, Varley 1995). Brandborg (1955) noted that goats in Montana and Idaho used the lowest available winter ranges that provide preferred combinations of broken terrain and vegetative cover. Smith (1977) found wintering goats in the Bitterroot Range used cliff habitats more than 70 percent of the time observed. Kuck (1977) found the selection of winter habitat for goats in the Lemhi Mountains of Idaho was determined by the physical snow-shedding characteristics of an area rather than the forage types present.

Wintering goats show strong affinity for local sites where they restrict their movements dramatically in comparison with summer. The resulting distribution is often confined to critically small islands of habitat (Kuck 1977). In the Bitterroot Range, 36 goats occupied a linear distance of 3 miles throughout the winter (Smith 1977). Similarly, 17 wintering goats used 8.6 acres in the Swan Range of northern Montana (Chadwick 1973). In very severe winters, goats continue descending to lower elevations (Rideout 1977) or ascend to wind-swept ridges or mountain tops (Hjeljord 1973).

Various winter ranges in the GYA have been described. Peck (1972) reported goats using the Spanish Peaks area of the Madison Range moved to lower elevation winter ranges in Jack Creek and the Beartrap Canyon of the Madison River. Similarly, goats on the Beartooth Plateau are known to descend into the rocky canyons of drainages on the eastern front, including the Clarks Fork Canyon in Wyoming. There, they may be found as low as 5,000 feet in elevation. Mountain goats in the Crazy Mountains are thought to stay close to alpine areas using wind-swept ridges and cliffs (Lentfer 1955; T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In the Absaroka Range, goats are thought to descend to low, south-facing slopes and cliffs adjacent to summer ranges (T. Lemke, Montana Fish, Wildlife and Parks, personal communication; Varley 1995). One area of the Boulder River Canyon, which had steep semi-forested rock outcrops, was used by goats from the Absarokas in 1994 (Varley 1995).

HUMAN ACTIVITIES

Mountain goats are one of the least understood of all big game mammal species in North America (Eastman 1977, Chadwick 1983). Management has principally focused on the need for better population information and methods for setting harvest quotas (Brandborg 1955, Eastman 1977, Wigal and Coggins

1982). Eastman (1977) assessed research needs for goats in the U.S. and Canada and found non-hunting impacts resulting from human disturbance ranked within the top third among management priorities, though very little had been done on the subject.

Some human disturbances have been shown to alter goat behavior, and disturbance can affect physiology, distribution, habitat use, fecundity, and, ultimately, population health (Penner 1988). However, there is little known about winter recreation disturbances and their effects on mountain goats.

Throughout North America, some goat populations have been adversely affected by human developments, including logging (Chadwick 1973, Hebert and Turnbull 1977, Smith and Raedeke 1982) and mineral, coal, gas, and oil development (Hebert and Turnbull 1977, Pendergast and Bindernagel 1977, Smith 1982, Joslin 1986). These cases have predictive value for estimating the general effects of continual disturbance through human activities. In these cases, a decline in goat population levels occurred when development in or near goat habitats took place. The mechanisms for population declines were not clear but seem to be related to improved access for hunting or poaching (Chadwick 1973, Foster 1977, Hebert and Turnbull 1977, Smith and Raedeke 1982, Smith 1994), abandonment of habitat due to alterations or disturbance (Chadwick 1973, Hebert and Turnbull 1977, Pendergast and Bindernagel 1977), or continual stress as a result of human presence (Joslin 1986).

Controlling human access has been continually suggested as the management tool that will have the greatest effects on the long-term health of mountain goat populations (Chadwick 1973, 1983; Eastman 1977, Hebert and Turnbull 1977, McFetridge 1977, Wigal and Coggins 1982, Joslin 1986, Haynes 1992). Joslin (1986) states, "Motorized access in or near mountain goat habitat is probably the single biggest threat to goat herds throughout North America."

Several authors have looked at the effects of human disturbance on goats in the form of proximity to people, traffic, and noise during summer (Holroyd 1967, Singer 1978, Thompson 1980, Singer and Doherty 1985, Pedevillano and Wright 1987). Goats have shown tolerance, and, in cases without harvest or harassment, the ability to readily habituate to humans on foot as well as road traffic (Bansner 1978, Stevens 1983, Singer and Doherty 1985, Pedevillano and Wright 1987, Penner 1988). Penner (1988) writes, "Goats are adaptable and can habituate to potentially adverse stimuli if they are gradually acclimatized and negative associations are avoided." This possibility is best achieved when stimuli sources are localized and highly predictable (Penner 1988, Singer and Doherty 1985). Sudden, loud noises, however, from traffic (Singer 1978, Singer and Doherty 1985, Pedevillano and Wright 1987), blasting or drills (Singer and Doherty 1985, Penner 1988), and helicopters (Penner 1988, Coote 1996) still elicited extreme alarm responses from goats that have been habituated to human presence.

Many observers have found that goats that are approached on foot are either mildly evasive, tolerant, or curious. Consequently, these observers believe that most human foot traffic is of minimal impact to goats (Brandborg 1955, Holroyd 1967, Thompson 1980, Pedevillano and Wright 1987). Although quite rare, confrontations with aggressive goats have been reported when humans and goats come into close quarters (Holroyd 1967, Chadwick 1983). Goats react by stamping their front feet, pawing the ground, and arching their necks when threatened by humans (Holroyd 1967). Quick, powerful movements coupled with very sharp horns can cause serious injury to humans in the course of handling goats. Anecdotal reports of goats on the Beartooth Plateau attest to the occasional aggressive nature of goats around humans. Driven by hunger for minerals, these goats have, on occasion, come into human camps knocking down tents and equipment.

Some biologists in the GYA have expressed concern about potential conflicts between humans and goats, but there are no documented, actual, ongoing conflicts. Outside the GYA on the Sawtooth National Forest and Sawtooth National Recreation Area in Idaho, special management restrictions on winter recreation, including foot, snow machine, and helicopter travel, have been established. Mitigation measures, including area restrictions, closures, and other regulations, were enacted to minimize the potential for disturbances to wintering goat populations (Hamilton et al. 1996, USFS 1997).

POTENTIAL EFFECTS

Human activities are capable of causing disturbances detrimental to mountain goat populations. While the cases that exist do not specifically refer to winter recreation, they do demonstrate the process by which human impact may alter goat behavior, habitat use, and stress levels potentially leading to population declines. Because of low productivity and narrow habitat requirements, goats can be considered a fragile wildlife resource, particularly while on winter ranges (Smith 1982, Chadwick 1983, Smith 1984, Wigal and Coggins 1988).

Because of the remote and rugged nature of goat wintering habitats, recreational use of such areas is unlikely. However, any use could potentially be detrimental. Abandonment of habitats or increased stress related to frequent encounters could be elicited through recreational activities including snowmobiling, skiing (downhill, cross-country, or telemark skiing accessed by helicopter or from the ground), snow-boarding, and ice-climbing.

Because mountain goats are sensitive to loud noises, snowmobiles and helicopters could affect their behavior depending upon the proximity and duration of the disturbance (Singer and Doherty 1985, Pedevillano and Wright 1987, Côté 1996). In the GYA, most occupied goat winter range occurs within established national wilderness areas where motorized travel is strictly prohibited. In assessing management considerations, the Idaho Department of Fish and Game identified use of helicopters for skiing as an activity potentially detrimental to goats. Where the two are in conflict, goats require protection (Idaho Department of Fish and Game 1990).

Nonmotorized users in close proximity to wintering goats may also affect goats in terms of the energy expended to avoid these users. Depending upon winter severity, energy expended avoiding recreationists could be costly and, therefore, cause harm to individuals and, in the long-term, to populations. Biologists have expressed concerns about an increasing amount of ice-climbing taking place in mountain goat habitats. The extent of this potential disturbance is unknown. Ice climbing may need to be monitored as a potential source of disturbance in particular situations, although, because it is a highly localized activity lacking loud noises or other disturbance factors, long-term effects would likely be minimal.

Although accounts of goats injuring humans exist, goats generally do not pose a safety hazard to humans. Only in unusual cases involving habituated goats in frequent, close proximity to humans would such a concern exist.

Mountain goats in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(6) Backcountry motorized areas
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation areas

Given the susceptibility of mountain goats to human disturbance, particularly during the months of winter, there is potential for negative impacts to goats as a result of winter recreational activities. However, there are no known cases of conflict in the GYA at this time. Seemingly, conflicts are being avoided between winter recreationists and mountain goats. Possible explanations for this conclusion include:

1. Conflicts may be occurring that are unknown to officials. It would be likely that any major conflicts would not escape attention, though the occasional, minor conflict could go unreported for some time. Minor conflicts may occur in association with wilderness trespasses and, thus, remain unreported or undetected. In most cases, it appears that wilderness designation and area use limitations have adequately protected mountain goat habitats from motorized-related disturbances in the GYA.
2. Because mountain goat winter range is inaccessible and precipitous, goats and recreationists are not often coming into conflict. For recreation, humans tend not to seek the combination of rocky, rugged terrain, and low-snow conditions required by mountain goats. Rather, snowmobilers and skiers prefer deep snow conditions, which are typically avoided by goats. The discrepancy in site preferences appears to be a factor in mutual avoidance by goats and humans during winter. While ice climbing does occur in goat winter range habitats, the effects of this form of recreation are unknown. Ice climbing is localized at specific sites and is predictable in terms of repeated use. These are two characteristics that goats seem to require for tolerance or habituation; therefore, ice climbing may not pose a significant threat to goats.

Management Guidelines

The impacts of human disturbance on goat populations have been clearly demonstrated in numerous cases; however, these cases conspicuously lack a clear case demonstrating the effects of recreation on goats during winter. Based on no known cases of conflict in the GYA, no immediate management recommendations are offered. If, however, cases of conflict occur in the future, restrictions on human use should be implemented to protect mountain goats. Such restrictions might include area closures, a permitting system that would regulate visitor numbers, and criteria for the use of helicopters in the area of mountain goat winter range.

A general lack of information on the winter habits and resource requirements for mountain goats may require further ecological studies. It would be useful to more specifically locate mountain goat winter ranges in the GYA and compare them with backcountry recreation use areas. Overlap can then be examined so that potential areas for conflict can be identified. If a significant overlap exists or conflict arises, management options can be considered and implemented.

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EFFECTS OF WINTER RECREATION ON SUBNIVEAN FAUNA

Subnivean fauna are small animals that live under the snow during the winter. They include such species as shrews, voles, pocket gophers, and mice.

LIFE HISTORY

Subnivean mammals are often active both day and night and are active throughout the year. They spend most of their time in or on the ground, and, during winter, they are most often found under the snow. Generally they are short lived but have relatively high reproductive rates.

These mammals eat a wide variety of foods that can be obtained from above or below the ground. Shrews eat primarily insects, other invertebrates, and some small mammals. A vole's diet may include green vegetation (grasses, seeds, grain, and bark). Tubers, roots, and some types of surface vegetation are preferred by pocket gophers, and mice generally feed on seeds, insects, or green vegetation.

Ecologically, these mammals are important prey species for a wide variety of birds and mid-sized carnivores.

HUMAN ACTIVITIES

It has been suggested that compacting snow by mechanical grooming or even by substantial activity on foot (skiing or snowshoeing) could have a negative impact on small mammals that spend their time under the snow in the winter.

POTENTIAL EFFECTS

The subnivean environment protects life below the snow from some impacts of winter, such as wind and cold. The environment under the snow has relatively stable temperatures, and the loss of energy from the organisms that live there is slowed. However, factors such as light, carbon dioxide, oxygen, and moisture may have more effect on the animals that live in this environment than on those that live above the snow (Halfpenny & Ozanne 1989).

Light penetration to plants under the snow may initiate plant growth and seed germination late in the winter, thereby providing a food source for mammals. Consumption of plants with phenolic compounds (which are found in growing grasses and other plants) is possibly a cue for the initiation of the reproduction process in some mammals (Halfpenny & Ozanne 1989). Carbon dioxide may accumulate in varying levels of concentration under the snow. Higher concentrations of carbon dioxide may affect the physiological functions of plants and animals, possibly resulting in the reduced ability of subnivean animals to find food or avoid predators (Halfpenny & Ozanne 1989). Water running through snowpack can cause flooding at ground level and below, and, especially during spring runoff, subnivean animals may drown or die of hypothermia (Halfpenny & Ozanne 1989).

Most research relating to the impacts of winter recreation on subnivean fauna has concerned the effects of snow compaction due to snowmobiles on the animals. One of the potential impacts of snow compaction is alteration of the snow microclimate, especially the physical and thermal aspects (Corbet 1970). Some of the possible changes in snow conditions resulting from snow compaction include a decrease in subnivean air space, a change in temperature, and accumulation of toxic air under the snow (Jarvinen and Schmid 1971, Schmid 1971a and b). Temperature changes may result in animal movements under the snow being limited, the suitability of a site for seed germination being reduced, and winter mortality of subnivean wildlife being increased (Keddy et al. 1979). There is a possibility that carbon dioxide could accumulate under the snow to levels that are toxic to small mammals. Carbon dioxide tends to flow downhill. If a compacted area is located at the bottom of a hill or even on a side slope, carbon dioxide accumulation could be fatal to the small mammals attempting to move through the area under the snow (H. Picton, Montana State University, personal communication).

According to Halfpenny & Ozanne (1989), skiers may do more damage to the snowpack than snowmobilers because narrow skis cut deeper into the snowpack and because skis have a greater footload (amount of weight per surface area) in comparison to a snowmobile track. For both ski tracks and snowmobile tracks, multiple passes over the same track will have more impact than a single pass. The larger the area of compaction, the greater the possible impact to subnivean fauna. If the habitat area is small, if rare species are present in the area, or if the activity is not restricted to narrow paths, impacts to subnivean life may be substantial and damaging (Halfpenny & Ozanne 1989).

Subnivean fauna in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(4) Groomed motorized routes
(5) Motorized routes
(7) Groomed nonmotorized areas

MANAGEMENT GUIDELINES

The lack of information about impacts to subnivean mammals from winter use makes it difficult to draw conclusions. However, there is the potential for an increase in winter mortality of these animals because of the impacts of snow compaction. Until more research is completed in this area, the only management guideline is to encourage more research on the subject, especially in areas where widespread and high intensity snowmobiling or skiing occurs near comparison control areas.

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BIRDS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BALD EAGLES

POPULATION STATUS AND TREND

Nesting, wintering, and migrating populations of bald eagles (*Haliaeetus leucocephalus*) occur in the Greater Yellowstone Area (GYA). Bald eagles are protected under the Migratory Bird Treaty Act of 1918 (16 U.S. Code 703) and the Bald Eagle Protection Act of 1940 (16 U.S. Code 668). Bald eagles were initially listed as an endangered species under the Endangered Species Act of 1973 (U.S. Code 1531, 1982 amended), but on July 12, 1995, the bald eagle's status was downlisted to threatened in the lower 48 states. This action did not alter those conservation measures already in place to protect the species and its habitats.

Because of the eagle's initial status as endangered, the Pacific States Bald Eagle Recovery Team was formed (the GYA is part of the Pacific Recovery Area). The team produced the Pacific Bald Eagle Recovery Plan (USFWS 1986), which addressed the recovery of bald eagles in Washington, Oregon, California, Nevada, Idaho, Montana, and Wyoming. Regionally, other teams were formed, and the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem was issued in 1983 (revised 1996), and the Montana Bald Eagle Management Plan was issued in 1986 (revised 1994). Both plans identify threats to the bald eagle and provide management direction for population recovery in the respective areas.

Three population units were delineated in the GYA based on bald eagle natural history and the elevation, climate, and vegetation of the units (GYBEWG 1996). The Snake Unit includes bald eagle breeding areas associated with the Snake River in northwestern Wyoming and southeastern Idaho. The Continental Unit includes the watersheds in southwestern Montana, the upper Henrys Fork, southeastern Idaho, and northwestern Wyoming. The Yellowstone Unit includes most of Yellowstone National Park.

Between 1970 and 1995, the bald eagle population in the GYA increased exponentially. There were 111 known breeding areas in 1995 (GYBEWG 1996). Population growth has been attributed to the significant reduction of environmental contaminates, such as DDT (pesticide), and the initiation of intensive nesting surveys (Flath et al. 1991).

LIFE HISTORY

The average life span of a wild bald eagle is estimated to be between 10 and 18 years (MBEWG 1994). Bald eagles first breed at 6 to 7 years (Harmata and Oakleaf 1992) after adult plumage is acquired (Stalmaster 1987). Nest building most commonly occurs during the autumn, late winter, and early spring (October to April), although nest repair may occur during every season for well-established pairs. Alternate nests may be present in a breeding area. Incubation can begin as early as the first week of February and as late as the last week of March (Swensen et al. 1986, Harmata and Oakleaf 1992, Whitfield 1993, Stangl 1994) and lasts 35 days. Bald eagles are very sensitive to disturbance during nest building, egg laying, and incubation.

Bald eagles are opportunistic feeders and prey on fishes, waterfowl, lagamorphs, some ground-dwelling mammals, as well as ungulate carrion. Bald eagles also steal prey from other eagles, osprey, otters, and many other species (Stalmaster 1987, Harmata and Oakleaf 1992, Stangl 1994).

In the GYA, adult breeding pairs of eagles may or may not migrate out of the ecosystem during the winter (Harmata and Oakleaf 1992). Juvenile, immature, and adult eagles migrate at different times, therefore, age ratios of a population may differ during the winter. Juveniles migrate earlier in the autumn (Stalmaster 1987, Harmata and Oakleaf 1992) and may travel farther than sub-adults or adults (Stalmaster 1987). Band encounters and radio tracking of juvenile and immature bald eagles produced in the GYA indicated that virtually all birds leave the ecosystem in the first autumn after fledging. Juveniles return in mid-April to early May and appear to remain within the GYA during the summer. Juvenile eagles originating in Canada winter within the GYA.

Habitat

Wintering Habitat

Bald eagle winter habitat is generally associated with areas of open water (unfrozen portions of lakes and free-flowing rivers) where fishes and/or waterfowl congregate (Swensen et al. 1986, Stalmaster 1987, GYBEWG 1996). Most winter habitats include major rivers and large lakes. Eagles will forage on high-quality foods away from aquatic areas, in particular, upland areas where ungulate carrion, game birds, and lagomorphs are available (Swenson et al. 1986). Ungulate carrion associated with late-season hunter harvests and big game wintering areas are also important to wintering bald eagles (GYBEWG 1996).

Nesting Habitat

Nesting habitat varies among units in the GYA. Nest sites are generally distributed around the periphery of lakes, reservoirs, and along rivers. Nests are most commonly constructed in mature or old-growth stands of large diameter trees that are multi-layered and contain a variety of species, primarily Douglas fir (*Pseudotsuga menziesii*), black cottonwood (*Populus trichocarpa*), and spruce (*Picea* spp.). Large emergent trees and snags provide important nesting and perching habitat (Wright and Escano 1986). Bald eagles display strong fidelity to a breeding area and often to a specific nest.

An available prey base may be the most important factor determining nesting habitat suitability (Swensen et al. 1986, Harmata and Oakleaf 1992, MBEWG 1994), nesting density (Dzus and Gerrard 1993), and productivity (Hansen 1987) of bald eagles. Bald eagles usually nest as close to maximum foraging opportunities as possible, although human activity will be avoided (Harmata and Oakleaf 1992).

Roosting Habitat

Like nesting and perching trees, roost trees are typically mature or old conifers or cottonwoods. Preferred roosting habitat includes a protected microclimate that provides shelter from harsh weather and is characterized by tall trees that extend above the forest canopy and by locations that provide clear views and open flight paths (Stalmaster 1987). Roost locations lie within the breeding territory during the breeding season. Bald eagles may roost in the nest or nest tree. As nestlings grow, the adults may roost farther away from the nest site (Stalmaster 1987).

In many areas, night communal roosts are important during the fall and winter months. Although winter roosting habitat is not necessarily close to water or in close proximity to food sources, the availability of an abundant source of food, of foraging perches, and of secure night-roost sites away from human activities are important habitat components (GYBEWG 1996, MBEWG 1994).

Human Activities

Bald eagles may be affected by a variety of recreational, research, resource, and urban development activities. Pesticides, poisoning, electrocution, vehicle collisions, and shooting have directly affected eagles. Various types of human activities that influence the environment have indirectly affected eagles (Mathisen 1968, Knight and Knight 1984, Stalmaster 1987, Buehler et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992).

Management concerns initially focused on permanent alterations of bald eagle habitat, such as cutting down nest trees. However, recent studies have demonstrated the importance of protecting eagle habitat from temporary human activities, such as recreation (Stalmaster and Newman 1978, Knight and Knight 1984, Knight et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992). Many recreational activities are focused on or around major water bodies where bald eagles nest, roost, or forage, thereby increasing the potential for eagle–human interactions.

Temporary human activities have been shown to influence the behavior of wintering bald eagles (Stalmaster and Newman 1978, Knight and Knight 1984) and those in breeding areas (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994). Anthony et al. (1995) believe that the cumulative effects of recreational activities can have deleterious effects on eagle populations through reductions in survival, especially during the winter, and in reduced reproductive success (Montolopi and Anderson 1991).

Potential Effects

Bald eagles are generally food-stressed during winter. High levels of human activity can potentially increase energy demands on wintering bald eagles and result in increased mortality rates (Stalmaster and Gessaman 1984). Juvenile bald eagles have higher energy demands, are less efficient foragers, and spend more time trying to acquire food than adults. Therefore, they are more likely to be adversely impacted by human activities.

During the breeding season, bald eagles are most sensitive to human activities during nest building, egg-laying, and incubation (February 1 to May 30). Human activities during this time may cause nest abandonment. After young have hatched, a breeding pair is less likely to abandon the nest. However, eagles may leave the nest due to prolonged disturbances, exposing young to predation and adverse weather conditions (MBEWG 1994, GYBEWG 1996).

Bald eagle responses to human activities generally range from displacement to avoidance of the human activity to reproductive failure. Bald eagle responses also vary depending on type, intensity, duration, timing, predictability, and location of the human activity. Responses may be influenced by the presence of another eagle nearby, the eagle's physical and behavioral state, the nature of the human activity, and the time and location of the encounter (Anthony et al. 1995). Eagle responses to human activities may differ with populations (Fraser et al. 1985) and with individual pairs (Stangl 1994). Some bald eagles may habituate to human presence and become more tolerant of human activities (Knight and Knight 1984, Harmata and Oakleaf 1992, GYBEWG 1996).

Human activities during the winter and spring can reduce feeding activities of bald eagles (Skagen 1980). These activities can also displace eagles from foraging areas (Stalmaster and Newman 1978), alter use patterns (*i.e.*, eagles will avoid a feeding area for a period of time), or shift spatial- or temporal-use patterns (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994, Smith 1988).

Vehicular activities along prescribed routes or within strict spatial limits and at relatively predictable frequencies are least disturbing to bald eagles (McGarigal et al. 1991, Stangl 1994, GYBEWG 1996). However, slow-moving motor vehicles can disrupt eagle activities more than fast-moving motor vehicles (McGarigal et al. 1991). Snowmobiles may be especially disturbing, probably due to associated random movement, loud noise, and operators who are generally exposed (Walter and Garret 1981).

Bald eagles have been displaced by pedestrian activities (Stalmaster and Newman 1978, McGarigal et al. 1991, Stangl 1994) especially when the activities occur outside of predictable use areas (Harmata and Oakleaf 1992). Grubb and King (1991) found that pedestrians (hikers, anglers, and hunters) were the most disruptive type of human activities to bald eagles. Stangl (1994) found that a bald eagle pair used perches that were spatially separated from pedestrian angler activities. Bald eagles that forage on the ground are most sensitive to human activities (Stalmaster and Newman 1978, Knight and Knight 1984, McGarigal et al. 1991), therefore, human disturbances may have a greater impact on eagles foraging on fish or ungulate carcasses (Anthony et al. 1995).

Riparian habitat is an important component of bald eagle habitat. Recreational impacts on riparian areas, specifically impacts to cottonwood trees, could affect bald eagle perch habitat as well as availability of prey.

In the GYA, winter recreational activities that are most likely to affect wintering, migrating, and spring nesting bald eagles include: snowcoach and snowmobile traffic, cross-country skiing, telemark skiing, snowshoeing, dog sledding, late-season elk hunting, and antler collecting. (Bison management activities also have the potential to impact bald eagles.) Groomed trails are often located in riparian areas, and activities on these trails can begin as early as October and extend as late or later than June. A review of the literature revealed that research has not been completed to assess the effects of snowmobile or other winter recreational activities on bald eagle wintering or breeding habitat, but some documents referenced potential effects of snowmobile activities (Shea 1973, Alt 1980, Harmata and Oakleaf 1992, Stangl 1994).

Bald eagles in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas
(2) Primary transportation routes
(3) Scenic driving routes
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

Management Guidelines

The Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) established a management goal "to maintain bald eagle populations in the GYA at high levels with high probabilities of persistence and in sufficient numbers to provide significance to the ecosystem, academic research, and readily accessible enjoyment by the recreational and residential public."

Management of bald eagle winter and spring habitat should focus on the presence and abundance of food for eagles that is usually associated with open water, the availability and distribution of foraging perches, the availability of secure night roost sites, and freedom from human harassment (Martell 1992).

Adequate monitoring of bald eagle wintering and nesting populations is fundamental to effective management. Bald eagles may be "urban" or "rural" (GYBEWG 1996) and respond differently to recreation activities. Eagles in the vicinity of high human densities and recreational activities may become habituated to human presence and tolerant of certain human activities. Urban eagles may be exposed to human activities that increase gradually, usually within defined spatial limits, while human activities that rural eagles are exposed to are distributed and moving randomly at varying intensities and often seasonal and abrupt. In some winter recreation areas, eagles will initiate nest building while snowmobile activities are at their highest levels.

The plan (GYBEWG 1996) suggested management guidelines with regard to winter recreation activities, including:

1. Encourage and support research to identify and quantify use and location of seasonal concentrations of bald eagles.
2. Establish buffer zones of 1,300 feet around high-use foraging areas with temporal restrictions from sunset to 10:00 a.m. in areas of high human use or establish site-specific modifications based on research findings.
3. Diurnal perching areas may not always be associated with primary foraging area. If separate, buffer zones of 650 to 1,300 feet around concentrated or high-use perches should be imposed, dependent on exiting vegetative screening. Temporal restrictions should be consistent with seasonal residency. Removal of trees, especially snags greater than 2 feet in diameter that are within 100 horizontal feet or 1,300 feet in elevational rise of greater than 30 degrees from shoreline should be discouraged on private land and prohibited on federal land. Single trees in upland foraging areas devoid of elevated perch sites should be retained.
4. Areas of winter and early spring waterfowl concentrations are important to wintering and migrating eagles. Efforts to enhance existing wetlands and development of new ones should be supported.
5. Strive to maintain visual, temporal, and spatial integrity of the roost site in order to provide for short- and long-term use by bald eagles. Manage critical and vital roost sites temporally and spatially. Areas within 1,300 feet of critical and vital roosts should be closed. Human activity beyond 1,300 feet may be disruptive if above the roost site. In such cases, methods to provide visual screening from the roost site should be explored and based on site inspection and recommendations of biologists. Closures for autumn roosts should extend from 1 October to 1 January, for winter roosts from 15 October to 1 April, for vernal roosts from 1 March to 15 April or determined by actual residency patterns of local eagles. Alternative schemes towards these ends should be encouraged to accommodate human values.
6. Strive for similar protection of secondary sites because they may evolve into critical or vital roosts through succession, fire, wind, or other catastrophe.

Guidelines have been developed in the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) and the Montana Bald Eagle Management Plan (MBEWG 1994) to provide management direction for bald eagles where there is little information on areas actually used. The GYBEWG (1996, pages 22–25) defined three zones within bald eagle breeding areas to which these guidelines apply. Zone boundaries should be altered after intensive study of eagle activity and development of site specific management plans. Guidelines and recommendations for the completion of management plans focused on bald eagle habitat or breeding areas.

ZONE I—NEST SITE AREA

The area within a ¼-mile radius of active nest sites should be maintained to protect nest site characteristics, including snags, nest trees, perch trees, roost trees, and vegetative screening. Any disturbances should be eliminated.

1. Human activity should not exceed minimal levels during the period from first occupancy of the nest site until two weeks following fledging (approximately 1 February to 15 August). Minimal human activity levels include essentially no human activity with the following exceptions: (1) existing patterns of ranching and agriculture, (2) nesting surveys and banding by biologist experienced with eagles, and (3) river traffic as defined by the GYBEWG (1996, page 22). Light human activity levels should not be exceeded during the rest of the year. Light human activity levels allow for day use and low impact activities such as boating, fishing, and hiking but at low densities and frequencies. Activities which are excluded include concentrated use associated with recreation centers (*i.e.*, picnic areas, boat landings) and helicopters within 650 yards of the ground.
2. Habitat alterations should be restricted to projects specifically designed for maintaining or enhancing bald eagle habitat and conducted only during September through January.
3. Human activity restrictions for Zone I may be relaxed during years when a nest is not occupied. However, light human activity levels should not be exceeded and land-use patterns should not preclude a return to minimal activity levels.

ZONE II—PRIMARY USE AREA

This zone includes the area ¼- to ½-mile from active nest sites in the breeding area where it is assumed that 75 percent of activities (foraging, loafing, bathing, etc.) of a bald eagle breeding pair occur.

1. Light human activity levels should not be exceeded during the nesting season. Moderate levels should not be exceeded during other times in the year. Moderate human activity include light impact activity levels but intensity of such activities are not limited. A limited number of recreation centers designed to avoid eagle conflicts may be considered. Other activities such as construction should be designed to specifically avoid disturbance. Designing projects or land uses to avoid eagle conflicts requires the sufficient data to formulate a site-specific management plan.
2. Habitat alterations should be carefully designed and regulated to ensure that preferred nesting and foraging habitat are not degraded.
3. Developments that may increase human activity levels and use patterns should not be allowed.

ZONE III—HOME RANGE

This area includes all suitable foraging habitat within 2.5 miles of active nest sites. Areas within the 2.5 mile radius of the nest that do not include potential foraging habitat may be excluded. However, the zone will include a 1,300 foot buffer along foraging habitat where the zone has been reduced.

1. Human activities should not exceed moderate.

2. Projects that could potentially alter the habitat of forage species should be carefully designed to insure availability of prey is not degraded. Adequate design of such projects will require data from site-specific management plans.
3. Terrestrial habitat alterations should ensure important components are maintained. Major habitat alterations should be considered only if site-specific management plans are developed and only if the alterations are compatible with management plans.
4. Permanent developments that are suitable for human occupancy should be avoided.

Other developments that may increase human activity levels should be carefully designed to ensure that objectives would not be exceeded for all three management zones. For example, active nest sites or any nest sites in the breeding area that have been active in the last five years if the active nest has not been identified should be protected.

Elk harvests occur during the fall and winter, and antler collecting occurs during the spring in various areas of the GYA. Gut piles and carcasses resulting from hunting activities provide a valuable foraging resource for wintering, migrating, and breeding bald eagles. Although some activities associated with the late hunt could displace bald eagles, hunting activities are generally completed early in the nesting season and the forage resulting from the harvest is probably more beneficial to bald eagles than the potential for displacement. This is not the case with antler collectors or “horn hunters.” Horn hunting activities generally occur during the spring when bald eagles are nesting and are most sensitive to human disturbances. Dispersed activities associated with horn hunting could potentially impact nesting bald eagles if the activities occur around the nest site or in the primary foraging area.

During winter and spring months, many wildlife species congregate at lower elevations. In the GYA, elk and moose are commonly observed along roadways and are periodically observed along designated and groomed snowmobile trails. Natural mortalities and road kill animals provide a winter and spring source of food for bald eagles. However, eagles can, in turn, become road kill victims themselves when foraging on carcasses located next to roads. Carcasses on and along roads should be moved away from the road edge in an effort to protect bald eagles and other scavengers. Similar incidents can occur along railroads where deer, elk, moose, and antelope may concentrate (J. Naderman, Idaho Department of Fish and Game, personal communication). Because a large portion of the GYA lies within the grizzly bear recovery area, road kill and some natural mortality carcasses are removed and are no longer available as a food source in an effort to reduce bear–human conflicts.

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EFFECTS OF WINTER RECREATION ON TRUMPETER SWANS

POPULATION STATUS AND TREND

The trumpeter swan (*Cygnus buccinator*) is a species of special concern in Idaho (Category A) and Montana, and a Priority 1 species in Wyoming. In March 1989, the Idaho Chapter of the Wildlife Society petitioned the U.S. Fish and Wildlife Service to add the Greater Yellowstone Area (GYA) trumpeter swan population to the threatened species list, but the population was not listed. Concern over the dramatic decline in the GYA trumpeter swan population led to the establishment of the Greater Yellowstone Trumpeter Swan Working Group in 1997.

During the 1800s and early 1900s, commercial trade in swan skins and habitat destruction reduced trumpeter swan populations to a fraction of historic levels. The species neared extinction in the lower 48 states, and isolated areas of protected habitat were critical to the survival of wild trumpeter swans (Banko 1960). The discovery of swans in the Centennial Valley in the 1930s led to the eventual establishment of Red Rocks Lakes National Wildlife Refuge. Management efforts at the refuge, as well as in a few other areas, have helped maintain trumpeter swan numbers in recent decades (Banko 1960, USFWS 1996).

The GYA trumpeter swan population has fluctuated dramatically and declined in recent years to the levels of the 1940s. Areas inside and outside Yellowstone National Park provide habitat for both resident and migratory swans. One theory for the decline is that traditional migration patterns and knowledge of important winter and spring habitats were lost as the species neared extinction. Another theory is that the swan population never migrated out of the GYA in large numbers. As a result, virtually all of the breeding trumpeter swans of Canada and the Greater Yellowstone Area share the same high-elevation winter habitat in the GYA (T. McEneaney, Yellowstone National Park, personal communication).

More than 10,000 swans currently exist in the wild. The Pacific population, representing most of the wild swans, breeds in Alaska and winters along the Pacific Coast from Alaska south to Washington (Ehrlich et al. 1988, Gale 1989). The mid-continental population of approximately 300 birds winters in the GYA. About 55 percent of these birds are year-round residents; the remainder migrate north and spend the summer in Canada (Gale 1989).

Currently, the swan population in the GYA has exhibited declining productivity. In Yellowstone National Park, no cygnets were produced in 1996 or 1997. In 1995, two of eight nest attempts were successful in the park, and six cygnets were produced, but only two fledged. In 1994, five cygnets fledged (NPS 1996; T. McEneaney, Yellowstone National Park, personal communication).

Winter habitat in the GYA is shared by resident and non-resident swans. Winter is a critical time for swans in the GYA as they are are vulnerable to reduced flows of water, heavy ice formation, unusually severe winter weather, disease, and environmental pollution. During the winter of 1988–89, about 100 swans died on the Henrys Fork as a result of ice formation on the river, which was due to low water flow and unusually low temperatures (Gale 1989; T. McEneaney, Yellowstone National Park, personal communication).

LIFE HISTORY

Trumpeter swans begin breeding between 3 and 6 years of age (most commonly at 4 or 5 years). They return to their breeding territories between February and late May. Most pairs remain together year-round and bond for life. The female normally lays between 4–6 eggs and incubates them for 33–37 days. The young hatch around late June and are precocial (they are mobile, downy, follow parents, and find their own food). The time from hatching to fledging ranges from 91–119 days. Cygnets remain with their parents through their first winter (Ehrlich et al. 1989, Gale 1989).

Trumpeter swan winter habitat is associated with open water, especially along the Henrys Fork River and the thermally influenced waters of Yellowstone National Park. Winter habitat must provide extensive areas of ice-free open water where aquatic plants are available (Gale 1989, USFWS 1996, Banko 1960).

Nesting Habitat

Breeding habitat is usually freshwater, especially the emergent vegetation on the margin of ponds, marshes, and lakes; however, brackish waters and slow-moving oxbows may be used. Nests are surrounded by water and built of aquatic and emergent vegetation, down, and feathers. Nests are often built on muskrat houses, beaver lodges, or small islands. Trumpeters generally use the same nest site for several years (Banko 1960).

Breeding territory in the GYA ranges from 25–37 acres and generally coincides with the size of the nesting lake. At Red Rocks Lakes National Wildlife Refuge in Montana, breeding territories average 32 acres. Breeding pairs exclude other trumpeter swans from their territories during the nesting and brooding period (USFWS 1996, Reel et al. 1989).

Human Activities

Swan tolerance for people varies by season and situation. Swans seem to be more tolerant of humans during the winter months, but display reduced tolerance as spring approaches, and they are preparing to migrate or breed (T. McEneaney, Yellowstone National Park, personal communication; Shea 1979). Observations by Shea (1979) indicated that swans on the Madison River showed more tolerance to winter recreationists than did swans on the Yellowstone River. Swans wintered on the Madison River within 55 yards of the road, which had heavy snowmobile traffic. Swans often retreated when visitors stopped, but continued to feed. Swans on the Yellowstone River generally reacted to recreationists by swimming farther out from shore (Shea 1979). Swans at Harriman State Park in Idaho had a more pronounced reaction to human disturbance; when approached by a person on skis or snowmobile, swans broke into flight, often moving several miles to another stretch of the river (Shea 1979).

Potential Effects

Swan conservation efforts in the GYA focus on ensuring adequate stream flows and protecting and enhancing nesting and wintering habitat. Nesting and brood-rearing seasons are critical times for swan survival and production. Disturbance by humans can have negative effects on trumpeter swans and other waterfowl. Henson and Grant (1991) note that:

> . . . disturbance can affect productivity in a number of ways including nest abandonment, egg mortality due to exposure, increased predation of eggs and hatchlings, depressed feeding rates on wintering and staging grounds, and avoidance of otherwise suitable habitat.

In winter, problems occasionally arise when recreationists approach swans too closely. This kind of activity can lead swans to become habituated to humans, which may make them more prone to predation or roadkill. It can also lead to flushing swans from open water, resulting in increased energy requirements and a loss of energy reserves essential to surviving the winter and hatching and rearing young. The effect is exacerbated by the number of times a swan experiences disturbances.

Aune (1981) found that swans appeared to become habituated to moving snowmobiles, but that they fly or swim away upon approach by foot or ski or when a snowmobiler stopped. Aune noted that, in general, animals function best in a predictable environment. Groomed routes, both for snowmobilers and skiers, create a more predictable environment.

High cygnet mortality prior to fledging can to be related to the poor condition of nesting females following severe winters and/or late, cold springs. However, Maj (1983) found that mortality is more site- or pair-specific and not entirely related to the nutritional status of the laying female. Maj also noted that 130–190 days are required to lay an average clutch of five eggs, incubate the eggs to full term, and raise the cygnets to fledging. Limitations to breeding time may be an important factor in the GYA where only approximately 90 frost-free days occur each year. Drought conditions are also an important factor in cygnet mortality.

Trumpeter swans in the GYA are particularly affected by human use of the following Potential Opportunity Areas as well as any opportunity area that has open water:

(1) Destination areas
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation area

MANAGEMENT GUIDELINES

- Designating snowmobile and ski trails away from open waters used as winter habitat by swans can mitigate winter recreational impacts on the birds.
- Special restrictions may need to be implemented on open-water snowmobiling in areas that swans routinely use for feeding. These measures would reduce the energetic expenditures resulting from disturbance.
- Some concern has been raised about the effects of snowmobile noise on swans. At this time, no information is available on this subject.

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